

eppendorf



Standard Operating Procedure

Standard Testing Procedure for Manual Dispensing Systems

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1 Operating instructions

1.1 Glossary

A

Accuracy

Accuracy of the actual value compared to the set value.

Additional volume

The total of the remaining stroke and the reverse stroke.

Adjustment

Mechanical change to the piston stroke, so that the error of measurement compared to the set value is as small as possible and within the device specification.

Air-cushion principle

Design characteristic of piston-stroke pipettes. An air cushion separates the liquid in the plastic tip from the piston inside the pipette. The piston moves the air cushion, which acts like an elastic spring.

Autoclaving

Thermal procedure to destroy microorganisms and disable viruses and enzymes. DNA is not destroyed completely. The items to be autoclaved are placed in water vapor in a pressure vessel at 121 °C and a positive pressure of 1000 hPa (1 bar) for 20 minutes.

B

Blow out

Movement of the piston into the lower position to blow out any residual liquid from the pipette tip. During pipetting operations, the liquid from the blow-out is part of the dispensing volume. During reverse pipetting operations, the liquid is **not** part of the dispensing volume.

Bottle-top buret

Piston burets are used for dispensing liquids until external criteria (such as, pH, conductivity) have been met. Dispenser for dispensing large amounts of fluid. Maximum dispensable volume is equal to the bottle's contents. This group includes the Top Buret M and the Top Buret H.

Bottle-top dispenser

Dispenser which can dispense liquid once per aspiration. This group includes the Varispenser and the Varispenser plus.

C

Calibration

Measuring process to reliably and reproducibly determine and document the error of measurement of a dispenser.

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Combitips advanced

Dispensing tip for all Eppendorf Multipettes and Repeaters. Dispenser tips are single-use consumables which function using the positive displacement principle and consist of a piston and a cylinder.

Cycle

Together, the upward piston movement (liquid aspiration) and downward piston movement (liquid dispensing) form a cycle.

D

DIN EN ISO 8655 standards series

The standards series defines requirements for volume measuring devices with stroke piston, including limit values for systematic and random error and the test methods.

Dispenser

A dispenser is a dispensing device that works according to the positive displacement principle. Multi-dispensers and single stroke dispensers are available.

Dispenser

Volume measuring device with stroke piston.

Dispensing step

Dispensing of the set partial volume with instruments working according to the positive displacement principle and electronic pipettes.

Dispensing system

A dispensing system consists of a dispenser and a matching dispensing tip.

Dispensing volume

Volume per dispensing step.

E

epT.I.P.S.

Eppendorf SE brand name for pipette tips without filter.

F

Fixed-volume pipette

The volume that can be dispensed is fixed and cannot be changed.

Free jet dispensing

Dispensing of liquid without the dispensing tip (pipette tip, dispenser tip) touching the tube inner wall.

G

Gravimetric volume test

Mass determination for a dispensed volume under laboratory conditions. The dispensed volume is calculated based on the weight of the amount of liquid and the density value at the measuring temperature.

I

Increment

Step size or resolution. The smallest possible change by which a value can be increased.

L

Leak tightness

Impermeability to air or liquid. Dispensers must ensure that the area between the liquid and the piston is leak tight.

M

Maximum permissible errors

Specification of the highest or lowest permissible deviation of the dispensed volume from the nominal or useful volume range. For the maximum permissible errors, the systematic and the random errors are specified. The maximum permissible errors are specified in accordance with DIN EN ISO 8655 and in accordance with the manufacturer limits of Eppendorf SE.

Maximum volume

The maximum volume that can be used for dispensing.

Multi-dispenser

Dispensers that can dispense liquid multiple times per filling volume. The multi-dispensers include all Multipettes/Repeaters. Multi-dispensers are also referred to as manual dispensers.

N

Nominal volume

The nominal volume of a piston-stroke pipette and burette is imprinted, and is the maximum dispensing volume according to the manufacturer's specifications. For mechanical dispensers, the nominal volume depends on the volume of the dispenser tip and the highest selection dial setting. For electronic dispensers, the nominal volume depends on the volume of the dispenser tip and the largest adjustable volume.

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P

Piston-stroke pipette

The piston in the pipette moves up or down depending on the task. The liquid is aspirated into a pipette tip.

Positive displacement principle

Design characteristic of piston-stroke dispensers. The liquid is in direct contact with the piston of the dispensing tip (Combitip) during aspiration and dispensing operations.

Precision

The scattering range of the measured values around the set value. A small scattering range represents a high level of precision. A large scattering range represents a low level of precision.

R

Rack

Mount for tubes or pipette tips.

Random error

Imprecision. A measure for the scattering (standard deviation) of the measured values around the average value.

Remaining stroke

Liquid reserve. The liquid which remains after all dispensing steps have been completed.

Residual stroke lock

The residual stroke lock prevents dispensing of an incorrect volume if there is not enough liquid available for the dispensing volume.

Reverse stroke

After liquid aspiration, the piston is moved to a defined initial position. Liquid is dispensed during the piston movement. The reverse stroke is not a dispensing step.

S

Single stroke dispenser

Dispensing device that works according to the positive displacement principle. Single stroke dispensers are also referred to as bottle-top dispensers. The entire aspirated volume is dispensed in one go.

Stroke

The stroke is the distance traveled by the piston.

Systematic error

Inaccuracy. Deviation of the average value of the dispensed volumes from the selected volume.

V

Vapor pressure

This term refers to the pressure exerted by the vapor of a material (solid or liquid) in an enclosed container. The vapor is in equilibrium with the solid or liquid phase of the material. The vapor pressure increases when the temperature increases. Each pure liquid has a vapor pressure of 1013 hPa (mbar) at boiling point. Volume errors caused by high vapor pressure can be reduced by prewetting the tip.

Vessel

A micro test tube or a single well in a plate.

Viscosity

Viscosity describes the viscosity of liquids and suspensions. The dynamic or absolute viscosity is indicated in Pa·s or in mPa·s. In older literature, the unit P or cP is used (1 mPa·s corresponds to 1 cP). At room temperature, a 50% glycerol solution has a viscosity of approx. 6 mPa·s. As the glycerol concentration increases, viscosity increases considerably. Absolutely anhydrous glycerol has a viscosity of approx. 1480 mPa·s at room temperature.

W

Wall dispensing

Dispensing liquid against the tube wall. The pipette tip or the dispensing tip is held against the tube inner wall and the liquid is dispensed.

Z

Z factor

Also referred to as correction factor Z. The Z factor is used to convert a mass at a certain temperature and atmospheric pressure into a volume.

1.2 Preface

The standard test instruction summarizes the requirements for the test place, the necessary preparations, the execution of the test series and the evaluation of the measurement results, which are necessary for the calibration of a manual dispenser (mechanical and electronic).

In the first step it is necessary to maintain the dispenser (e.g. cleaning). In order to maintain the clarity of this document, reference is made to the corresponding operating manual for product-specific information. The leak test provides information on whether the dispensing system is leak-proof or not. However, it does not make any statements concerning the actual performance of the pipette and does not replace a general check by calibration.

The next step is the testing of the device, i.e. calibration. This is based on the data from DIN EN ISO 8655-6:2022 for gravimetric testing.

For pipettes, another step can follow: If it is determined during calibration that the pipette is not operating within the specified error limits, the instrument can be adjusted. Adjustment may be carried out only if errors due to handling, system or test equipment are excluded.

1.3 Version overview

Version number	Issue date	Change
15	2023-04	<ul style="list-style-type: none">Generally applicable module for copyright and disclaimer added.Adjustment for the new DIN EN ISO 8655-6:2022 standard version
14	2022-04	<ul style="list-style-type: none">Measurement errors for Reference 2: Table for special tips deletedMeasurement errors for Research plus: Table for special tips deletedEppendorf AG changed to Eppendorf SE
13	2021-07	<ul style="list-style-type: none">Correction of the measurement errors for the "Move It" multi-channel pipette
12	2021-04	<ul style="list-style-type: none">Editorial changes and revisionsThe pipette models "Reference", "Research", "Research pro" and "Multipette/Repeater" were removedThe multi-channel pipette "Move It" was addedThe dispenser "Varispenser 2/2x" was added
11	2019-05	<ul style="list-style-type: none">16-channel and 24-channel pipettes added to prefaceCalibration instruction of 16-channel and 24-channel pipettes addedCalibration instructions for multiple-channel pipettes specified more preciselyCorrection of the measured value deviations for Multipette M4 and Multipette E3/E3xNew volume models added to measured value deviations (Research plus and Xplorer plus)New tables for measuring value deviations of 16-channel/ 24-channel pipettes added (Research plus and Xplorer/ Xplorer plus)Editorial text corrections

Version number	Issue date	Change
10	2016-04	<ul style="list-style-type: none">• Chapter structure and contents completely revised and updated• Gravimetric testing of positive displacement systems with 30 measured values added• Product-specific information on cleaning, maintenance, autoclaving and adjustment deleted. Reference to the respective operating manual.• Calculation errors corrected• Formulas adjusted• Flow charts for the calibration procedure inserted• Multipette E3/E3x - Repeater E3/E3x added• Leak test adapted to current pipettes• Glossary expanded• Title and title photo changed
09	2014-01	<ul style="list-style-type: none">• Document number updated
08	2013-05	<ul style="list-style-type: none">• Pipette Reference 2 added
07	2013-04	<ul style="list-style-type: none">• Design change
01 – 06	-	<ul style="list-style-type: none">• Document control without change history

1.4 Supported Eppendorf dispensers

The standard test Instruction can be used for the following dispensers:

1.4.1 Mechanical piston stroke pipettes – air-cushion principle

- Reference 2
- Research plus

1.4.2 Electronic piston stroke pipettes – air-cushion principle

- Xplorer
- Xplorer plus

1.4.3 Mechanical piston stroke pipettes – hybrid system

- Varipette + Varitip S-System – Air-cushion principle
- Maxipettor + Maxitip S-System – Air-cushion principle
- Varipette + Varitip P – Positive displacement principle
- Maxipettor + Maxitip P – Positive displacement principle

1.4.4 Mechanical piston stroke pipettes – positive displacement principle

- Biomaster

1.4.5 Mechanical multiple-dispensers – positive displacement principle

- Multipette M4/Repeater M4
- Multipette/Repeater
- Multipette plus/Repeater plus

1.4.6 Electronic multiple-dispensers – positive displacement principle

- Multipette E3/E3x – Repeater E3/E3x
- Multipette stream/Repeater stream
- Multipette Xstream/Repeater Xstream

1.4.7 Mechanical single stroke dispensers – positive displacement principle

- Varispenser
- Varispenser plus
- Varispenser 2
- Varispenser 2x

1.4.8 Mechanical bottle-top burette – positive displacement principle

- Top Buret M
- Top Buret H

2 Maintenance information

Regular cleaning and maintenance of the dispensers ensures compliance with the specified values for the measurement error. The frequency of cleaning and maintenance of the individual dispenser depends on the degree of utilization and the chemicals that are dispensed with it. For dispensers which are used heavily or used for dispensing aggressive chemicals it makes sense to shorten the cleaning intervals.

Eppendorf recommends to use a maintenance log book for the dispensers or to add remarks on the maintenance activities that were carried out to the calibration protocols.

For service, we recommend sending the device to a service organization certified by Eppendorf SE.

The operating manuals of the individual dispensers contain information on cleaning, servicing, maintenance, sterilization and disinfection. Strictly follow all instructions given in the "Maintenance" chapter of the respective dispenser's operating manual.

-  The operating manuals are available on the following website:
www.eppendorf.com/manuals.

Before a calibration, the device must be cleaned and serviced.

Exception: If it is necessary to determine the actual condition of the dispenser to draw conclusions on analysis results, it may be useful to carry out the calibration before servicing the device. In this case, however, we recommend to repeat the calibration after cleaning and servicing the device.

2.1 Cleaning the piston stroke pipettes – air-cushion principle

2.1.1 Cleaning and disinfecting the lower part

Prerequisites

- Heavy contamination caused by ingress of liquid must be removed.
- Lower part has been removed and disassembled.

1. Remove piston grease.
2. Rinse the lower part with cleaning agent or decontamination agent or let it soak.
-  Observe the contact time recommended by the manufacturer.
3. Thoroughly rinse the lower part with demineralized water.
4. Let the lower part dry.
5. Grease the piston and the cylinder.
-  See instructions for use "Grease for pipettes".
6. Assemble the lower part.

2.2 Cleaning piston-stroke pipettes – Positive displacement principle

In the case of piston-stroke pipettes with positive displacement system, the piston is integrated in the pipette tip. This design feature protects the internal assemblies of the pipette against contamination.

- ▶ Clean the outside of the pipette.

2.3 Cleaning the multi-dispenser – Positive displacement principle

In the case of multi-dispensers, the piston is integrated in the dispensing tip. This design feature protects the internal assemblies of the multi-dispenser against contamination.

- ▶ Clean the outside of the dispenser.

2.4 Cleaning the single stroke dispenser

Single stroke dispensers are cleaned on the outside and the inside.

1. Clean the outside of the housing.
2. Flush the tube and piston system multiple times with a neutral cleaning solution.
3. Flush the tube and piston system multiple times with demineralized water.

2.5 Cleaning bottle-top burets

In the case of bottle-top burets, the piston comes into direct contact with the liquid to be dispensed. The dispenser must therefore be cleaned on the outside and the inside. The Top Buret is not autoclavable.

1. Clean the outside of the housing.
2. Flush the tube and piston system multiple times with a neutral cleaning solution.
3. Flush the tube and piston system multiple times with demineralized water.
4. Check leak tightness.

2.6 Decontamination before shipment



CAUTION! Use of a contaminated device may result in personal injury and damage to the device.

- ▶ Clean and decontaminate the device in accordance with the cleaning instructions before shipping or storage.

Hazardous substances are:

- solutions presenting a health hazard
- potentially infectious agents
- organic solvents and reagents
- radioactive substances
- proteins presenting a health hazard
- DNA

1. Please note the information in the "Decontamination certificate for product returns" document.

It is available as a PDF document on our website [www.eppendorf.com/
decontamination](http://www.eppendorf.com/decontamination).

2. Enter the serial number of the device on the decontamination certificate.
3. Enclose the completed decontamination certificate for returned goods with the device.
4. Send the device to Eppendorf SE or to an authorized service center.

3 Test intervals

The change of the systematic and random error of measurement is a gradual process. Aggressive chemicals, in particular, speed up this process. There is no general rule or basis for calculation for determining the appropriate time intervals.

It is possible to draw conclusions from calibration results recorded over an extended period of time to determine the individual calibration frequency for the device.

Test intervals may be stipulated by specific laboratory regulations. DIN EN ISO 8655 requires an annual calibration.

Shorter intervals for maintenance, servicing and calibration depend on the following factors:

- Degree of use
- Accuracy requirements for the dispenser
- Handling
- Chemicals
- Laboratory regulations

4 Types of testing

There are several different ways to test a dispensing system. The most simple and most current type of testing is a visual inspection during which the dispenser is checked for damage and soiling. The different types of testing are described in the following chapters.

Eppendorf SE recommends carrying out calibration in accordance with the gravimetric reference method described in DIN EN ISO 8655-6:2022

4.1 Visual inspection of all dispensers

- ▶ Inspect the tip cone for scratches or cracks.
- ▶ Inspect the dispenser for broken parts.
- ▶ Inspect the dispenser for external impurities.
- ▶ Check if the piston runs freely.

4.2 Visual inspection of single stroke dispensers and bottle-top burets

- ▶ Exchange liquid in case of crystallization.
- ▶ Clean the dispenser.
- ▶ Vent the system if air bubbles form.

4.3 Testing the tightness of dispensers with air-cushion principle

Prerequisites

- Ambient temperature is constant
 - Ambient temperature between 20 °C – 27 °C
 - Relative humidity > 50 %
 - Test tip epT.I.P.S.
 - Test liquid: demineralized water
 - Dispenser, test tip and test liquid are at ambient temperature
1. Set the pipette to nominal volume.
 2. Attach the pipetting tip.
 3. Fill and empty the pipetting tip 5 times.
This ensures the proper saturation of the vapour phase in the air cushion and prevents further evaporation of the test liquid.
 4. Aspire the nominal volume.
 5. Suspend the pipette vertically inside the support.
-  Hold the pipette with two fingers to keep it in vertical position. Make sure that the temperature of the fingers holding the pipette is not transferred onto the pipette.

4.3.1 Dispensing system is tight

The dispensing system is tight if, for the next 15 seconds, there are **no** drops of liquid at the pipetting tip.

4.3.2 Dispensing system is not tight

The dispensing system is not tight if drops of liquid are forming at the pipetting tip within 15 seconds.

1. Check the assembly of the pipette.
2. Check the piston seal for damage.
If the piston seal is damaged, the entire piston must be replaced including the seal.
3. Repeat the leak test.

4.4 Checking the leak tightness of dispensers with positive displacement principle

In positive displacement systems, the tightness is determined exclusively by the dispensing tip. All dispensing tips are single-use items and may leak during prolonged use.

In case of the single stroke dispensers and the bottle-top burette, air in the tube system is an indication of leakage in the piston/cylinder system. The leakage can be caused by crystallization, defective seals, a defect in the piston system or in the cylinder system.

- ▶ Remove crystallization from the device.
- ▶ If the cleaned device continues to leak, send the device to an authorized service center.

4.5 Conformity check

A completed calibration corresponds to a conformity check. A conformity check with a positive result confirms that the measurement errors of a dispenser are within the required tolerances.

During the conformity check, whether a dispensing system is within the specified measurement tolerances is checked. A calibration with 10 measured values per volume is used a reference measurement. A test can also be carried out with fewer measured values if this meets the customer's quality requirements. The user can define the limit values freely within the ISO limit values.

5 Prerequisites for gravimetric testing

To avoid a distortion of the measuring results, errors caused by test equipment and test method must be minimized.

5.1 Measuring place setup

A fully equipped measuring desk consists of:

- Analytical balance for single-channel pipettes
- Analytical balance with several load cells for multi-channel pipettes
- Evaporation protection (e.g. evaporation trap)
- Thermometer for liquid (0.2 K)
- Thermometer for air (0.3 K)
- Hygrometer (5 %)
- Barometer ($\pm 1 \text{ kPa}$)
- Stopwatch (1 s)
- Storage container for test liquid
- Test liquid (demineralized water)
- Test tips

5.1.1 Analytical balance

The analytical balance must meet the following requirements:

- Balance operates within the prescribed weighing tolerances
- Fast and stable display of weighing results
- Resolution of the balance suitable for the test volume

5.1.2 Single-channel balance

Nominal volume dispenser	Resolution of the single-channel balance
0.5 μL – 20 μL	0.001 mg
20 μL – 200 μL	0.01 mg
200 μL – 10 mL	0.1 mg
10 mL – 1000 mL	1 mg
1000 mL – 2000 mL	10 mg

5.1.3 Multi-channel balance

Nominal volume dispenser	Resolution of the multi-channel balance
0.1 µL – 20 µL	0.01 mg
20 µL – 200 µL	0.01 mg
200 µL – 10 mL	0.1 mg

5.1.4 Liquid reservoir

The reservoir must be selected so that all the liquid can be presented for the upcoming test.

5.1.5 Weighing vessel

Leading balance manufacturers offer special weighing vessels and evaporation protection (e.g. evaporation trap) for gravimetric testing of pipettes. The use of such devices results in stable weight values. Measurement errors caused by evaporation are significantly reduced, especially with small volumes.

The weighing vessel should meet the following requirements:

- Lockable
- Size suitable for test volume
- Ratio of height to diameter of at least 3:1

5.1.6 Measuring place

The measuring place should meet the following requirements:

- Draft-free
- Vibration-free workplace
- Relative humidity 45 % – 80 %
- Ambient temperature 20 °C – 27 °C (± 3 °C)
- No direct heat radiation

5.2 Test liquid

Distilled or de-ionized water must be used in accordance with ISO 3696:1991-06. The water temperature must not deviate by more than ± 0.5 °C from the temperature of the ambient air.

5.3 Temperature

The test room and all required materials for calibration must be at 20 °C (± 3 °C) 2 hours before beginning calibration with a maximum deviation of ± 0.5 °C during the test. If the pipette is used in a country where the reference temperature is 27 °C, 27 °C, ± 3 °C applies.

5.4 Test tips

All Eppendorf pipettes and dispensers must be tested with original Eppendorf pipette tips or dispensing tips.

- Piston stroke pipettes - epT.I.P.S.
- Multipettes and Repeaters – Combitip advanced
- Biomaster - Mastertip P
- Maxipettor - Maxitip P or Maxitip S-System
- Varipette - Varitip P or Varitip S-System

5.5 Data transfer and data evaluation

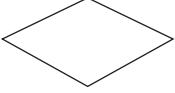
A calibration software is a useful means to automatically record the measured values obtained with gravimetric methods, convert measured values into corrected volumes and calculate the errors of measurement from these values.

5.6 Additional test conditions

The testing cycle duration (time required for conducting the weighing of a dispensed volume) must be kept as short as possible and kept uniformly from cycle to cycle. For all the dispensers that were mentioned, the test is carried out by determining the volume which is dispensed into the weighing vessel (Ex).

6 Performing the calibration

A calibration involves various steps that are described in this SOP. The following diagram provides an overview of the individual steps.

Symbol	Meaning
	Start or end of the procedure.
	A single action or a sequence of actions in the procedure.
	A branching and decision in the procedure.

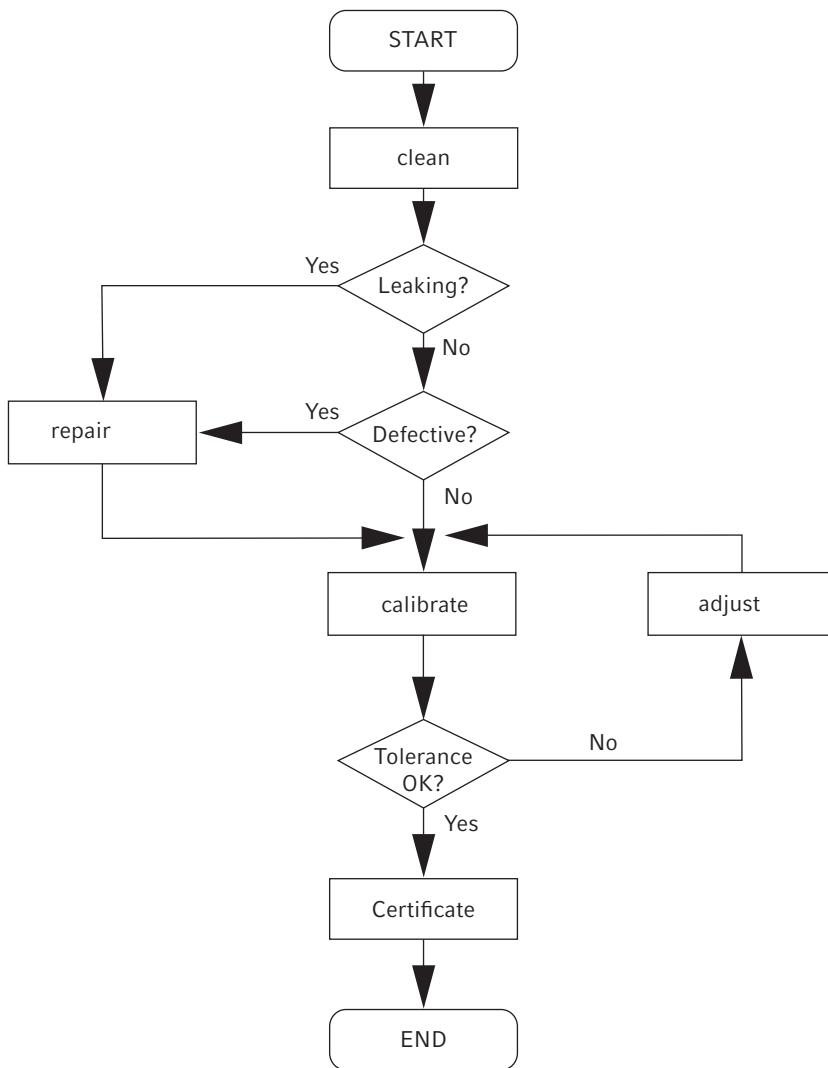


Fig. 6-1: Complete calibration procedure

6.1 Preparing the measuring place for calibration

6.1.1 Preparing the dispenser, test liquid and analytical balance

Prerequisites

- Dispenser has been cleaned.
 - Defective parts of the dosing unit have been replaced.
 - Dispenser is decontaminated and disinfected.
- Fill the test liquid.
- Have the dispenser and pipette tips ready for use at the measuring place.
- Allow the dispenser, pipette tips and test liquid to acclimatize for at least 2 hours in the test room.

6.1.2 Preparing a reusable 384 box for multi-channel pipettes with 16 channels

The reusable boxes must be prepared so that one reusable box contains all odd rows of pipette tips and the other reusable box contains all even rows of pipette tips.

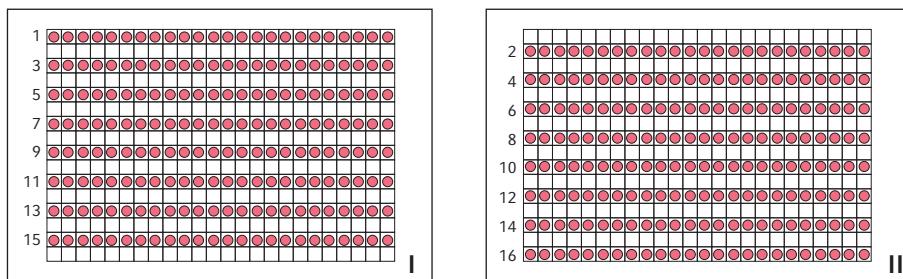


Fig. 6-2: Reusable boxes for test runs I and II

6.1.3 Preparing a reusable 384 box for multi-channel pipettes with 24 channels

The reusable boxes must be prepared so that one reusable box contains all odd columns of pipette tips and the other reusable box contains all even columns of pipette tips.

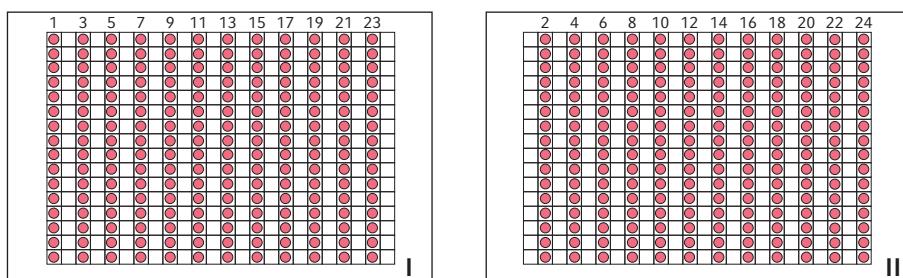


Fig. 6-3: Reusable boxes for test runs I and II

6.1.4 Preparing the documentation

- ▶ Print the checklist.
- ▶ Print the test report or prepare an Excel list.
- ▶ Start the calibrating software.

6.2 Checklists for the preparation of the calibration

The following checklists can be used in preparation to ensure that all necessary equipment is available at the time of calibration. For this reason, the tables contain checkbox columns (Yes, No, Not available).

The checklist is divided into the following sections:

- A – Test conditions
- B – Test liquid
- C – Dispenser
- D – Analytical balance
- E – Calibrating software

6.2.1 A – Test conditions

Number	Description	Yes	No
A01	Vibration-free weighing table is available.		
A02	Dispenser, pipette tips, test liquid etc. have ambient temperature.		
A03	The measuring place is draft-free.		
A04	Ambient temperature between 17 °C and 30 °C		
A05	Relative humidity between 45 % und 80 %		
A06	Document temperature, humidity and air pressure.		
A07	The tester can operate the dosing unit.		
A08	Document test data (name of tester, date, etc.).		
A09	Specify test method (manufacturer's specifications, ISO, laboratory standard, etc.).		
A10	Liquid discharge into the weighing vessel (Ex)		

6.2.2 B – Test liquid

Number	Description	Yes	No	Not available
B01	Test liquid is available (according to ISO 3696:1991-06).			
B02	Test liquid has ambient temperature.			
B03	Larger vessels are filled at least 2 h before calibration.			
B04	Evaporation trap is filled with test liquid at least 2 h before calibration.			
B05	Prefill weighing vessel with test liquid (approx. 3 mm).			
B06	Bottle-top burette: Test liquid filled at least 2 h before calibration.			
B07	Bottle-top dispenser: Test liquid filled at least 2 h before calibration.			

6.2.3 C – Dispenser

Number	Description	Yes	No	Not available
C 01	Dispenser has been cleaned.			
C 02	Defective parts have been replaced.			
C 03	Electronic dispenser: Battery is charged.			
C 04	Electronic multiple-dispenser: Mode “Dispensing” is set.			
C 05	Electronic pipette: Mode “Pipetting” is set.			
C 06	Mechanical dispenser: Nominal volume has been determined.			
C 07	Dispensing system with variable volume: Test volume is set.			
C 08	Piston-stroke pipette: The pipette tip has been attached correctly.			
C 09	Multi-dispenser: Dispenser tip has been inserted.			
C 10	The device is kept in the calibration lab for at least 2 h for acclimatization.			

6.2.4 D – Analytical balance

Number	Description	Yes	No
D 01	Balance is aligned horizontally.		
D 02	The balance is calibrated or a valid calibration certificate is available.		
D 03	Sensitivity is set according to the test volume.		
D 04	Weighing vessel volume is sufficient for 10 liquid discharges of the nominal volume.		
D 05	Balance is switched on at least 2 h before calibration.		

6.2.5 E – Calibrating software

Number	Description	Yes	No	Not available
E 01	Computer is switched on and connected to the analytical balance.			
E 02	Calibration software can record the measured values.			
E 03	Calibration software and analytical balance are ready for communication.			

6.3 Conducting a series of measurements

The measured values of a series of measurements should be determined in close chronological correlation. This reduces the risk of errors or deviations between the measured values.

6.3.1 Number of measured values

Single-channel pipette with variable volume:

- 10 measured values per testing volume

Multi-channel pipettes:

- 10 measured values per channel for each testing volume

6.3.2 Change of pipette tip

A new pipette tip in accordance with the following table must be used during the series of measurements.

Pipette tip 1					Pipette tip 2					Pipette tip 3					Pipette tip 4				
1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Measurement series 1					Measurement series 2					Measurement series 3					Measurement series 4				

6.3.3 Number of equipped tip cones - 4-channel and 12-channel lower parts

- i** All channels must be equipped with a pipette tip and filled with test liquid.

6.3.4 Number of equipped tip cones - 16-channel and 24-channel lower parts

- i** Multi-channel pipettes with a cone spacing of 4.5 mm must be calibrated in two passes. For technical reasons, only every second channel can be measured in one test run (minimum distance between two load cells is 9 mm).

6.3.5 Testing volume

For variable volume pipettes, the following volumes are checked in this order:

- 10% of the nominal volume or the smallest adjustable volume (select the larger of the two volumes)
- 50% of the nominal volume
- 100% of the nominal volume, or
- Optional: freely selectable test volume (e.g. requirement from laboratory regulation)

6.3.6 Immersion depths and wait times

Volume in [μL]	Immersion depth in [mm]	Wait time in [s]
≤ 1	1 – 2	1
> 1 – 100	2 – 3	1
> 100 – 1000	2 – 4	1
> 1000 – 20000	3 – 6	3

6.3.7 Presaturating the air cushion

The air cushion in the air-cushion pipettes is presaturated to minimize evaporation and reduce measurement errors. For positive displacement systems and multi-dispensers, presaturation is used to minimize the size of the aspirated air bubble. Single-dispensers and burettes are filled until there are no more air bubbles in the system.

Presaturation before calibration:

- Air-cushion pipettes – Absorb and dispense 5 times
- Positive displacement systems and multi-dispensers – Absorb and dispense 1 time
- Single-dispenser and burettes – not necessary

6.3.8 Overview of the calibration procedures

Differences between the device groups become apparent during the calibration procedure. The following overview illustrates this.



All pipettes are calibrated using the forward pipetting mode.

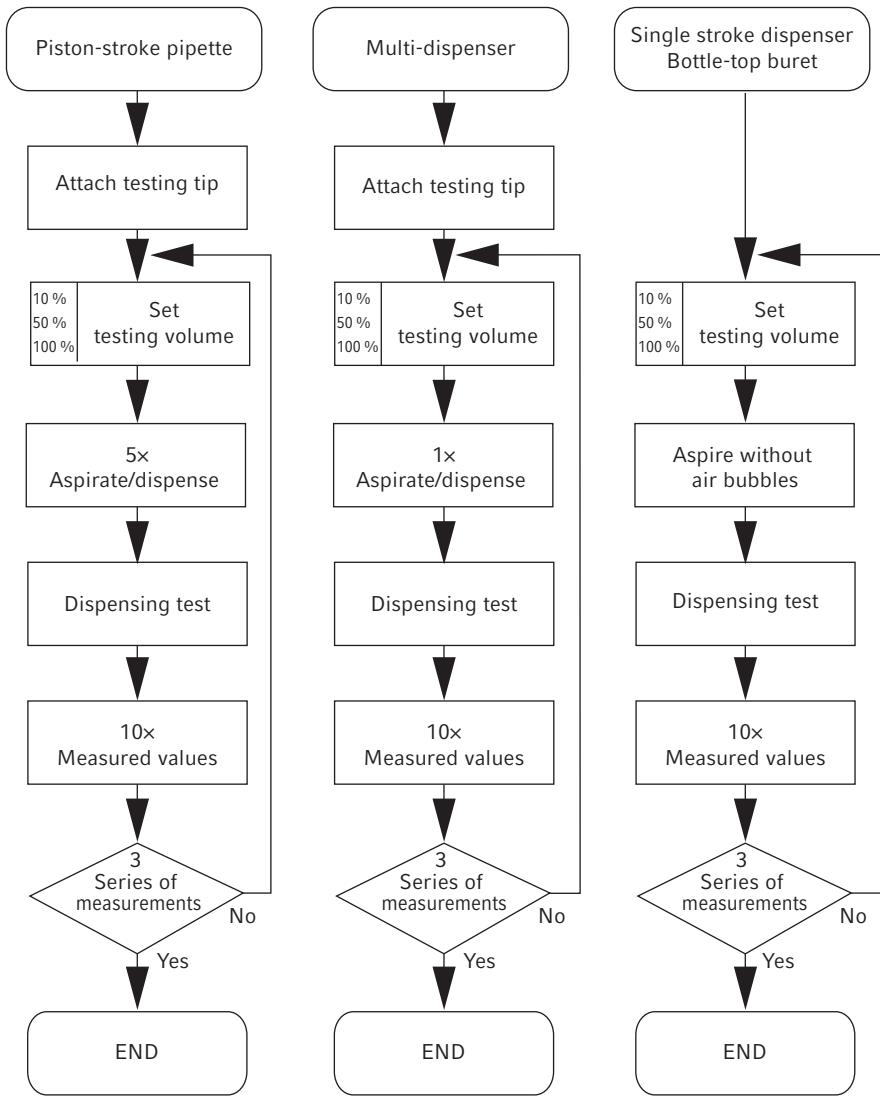


Fig. 6-4: Calibration procedure of the device groups

6.3.9 Determining measured values - mechanical single-channel pipettes

Prerequisites

- Test tip has been attached.
1. Adjust the test volume.
 2. Absorb and dispense the test liquid 5 times.
 3. Immerse the test tip vertically in the test liquid.
 4. Maintain immersion depth and absorb the test liquid slowly and evenly.
 5. Wait until liquid aspiration is complete.
 6. Remove the test tip from the liquid.
 7. Set the test tip against the inner wall of the weighing vessel at an angle of 30° – 45°.
 8. Perform test dispensing procedure.
 9. Determine measured values for each test volume.

6.3.10 Determining measured values - mechanical multi-channel pipettes with 4.5 mm cone distance

For multi-channel pipettes with a cone spacing of 4.5 mm, the measured values for a test volume must be determined in two test runs. In test run I, all channels with odd numbers are measured and in test run II, all channels with even numbers are measured.

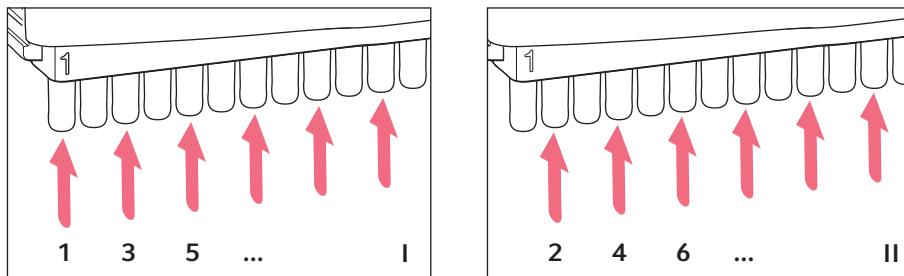


Fig. 6-5: Equipping the tip cones for test runs I and II

6.3.11 Test run I and II

Prerequisites

- A reusable box with pipette tips for test run I has been prepared
 - A reusable box with pipette tips for test run II has been prepared
1. Take up pipette tips for test run I.
 2. Adjust the test volume.
 3. Absorb and dispense the test liquid 5 times.
 4. Immerse the test tips vertically in the test liquid.
 5. Maintain immersion depth and absorb the test liquid slowly and evenly.
 6. Wait until liquid aspiration is complete.
 7. Remove the test tips from the liquid.
 8. Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.
 9. Perform test dispensing procedure.
 10. Determine measured values for the test volume.
 11. Eject the test tips.
 12. Take up pipette tips for test run II.
 13. Absorb and dispense the test liquid 5 times.
 14. Immerse the test tips vertically in the test liquid.
 15. Maintain immersion depth and absorb the test liquid slowly and evenly.
 16. Wait until liquid aspiration is complete.
 17. Remove the test tips from the liquid.
 18. Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.
 19. Perform test dispensing procedure.
 20. Determine measured values for the test volume.
 21. Determine measured values for each test volume using test runs I and II.

6.3.12 Determining measured values - mechanical multi-channel pipettes with 9 mm cone distance

Prerequisites

- Test tips have been attached to all channels.
1. Adjust the test volume.
 2. Absorb and dispense the test liquid 5 times.
 3. Immerse the test tips vertically in the test liquid.
 4. Maintain immersion depth and absorb the test liquid slowly and evenly.
 5. Wait until liquid aspiration is complete.
 6. Remove the test tips from the liquid.
 7. Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.

8. Perform test dispensing procedure.
9. Determine measured values for each test volume.

6.3.13 Determining measured values – mechanical multi-channel pipettes with adjustable cone spacing

1. Set the cone spacing to 9 mm.
2. Adjust the test volume.
3. Absorb and dispense the test liquid 5 times.
4. Immerse the test tips vertically in the test liquid.
5. Maintain immersion depth and absorb the test liquid slowly and evenly.
6. Wait until liquid aspiration is complete.
7. Remove the test tips from the liquid.
8. Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.
9. Perform test dispensing procedure.
10. Determine measured values for each test volume.

6.3.14 Determining measured values - electronic single-channel pipettes

The electronic pipettes are tested in one operating mode “Standard pipetting” (**Pip**). Errors of measurement occur equally in all operating modes.

1. Set absorption speed and dispensing speed.
2. Set the operating mode.
3. Attach the test tip.
4. Adjust the test volume.
5. Absorb and dispense the test liquid 5 times.
6. Immerse the test tip vertically in the test liquid.
7. Maintain immersion depth and absorb test liquid.
8. Wait until liquid aspiration is complete.
9. Remove the test tip from the liquid.
10. Set the test tip against the inner wall of the weighing vessel at an angle of 30° – 45°.
11. Transfer the test liquid to the tube inner wall.
12. Determine measured values for each test volume.

6.3.15 Determining measured values - electronic multi-channel pipettes with 4.5 mm cone distance

For multi-channel lower parts with a cone spacing of 4.5 mm, the measured values for a test volume must be determined in two test runs. The minimum distance between two load cells is 9 mm. In test run I, all channels with odd numbers are measured and in test run II, all channels with even numbers are measured.

The electronic pipettes are only tested in one operating mode. Errors of measurement occur equally in all operating modes. A correction has an equivalent effect on all modes.

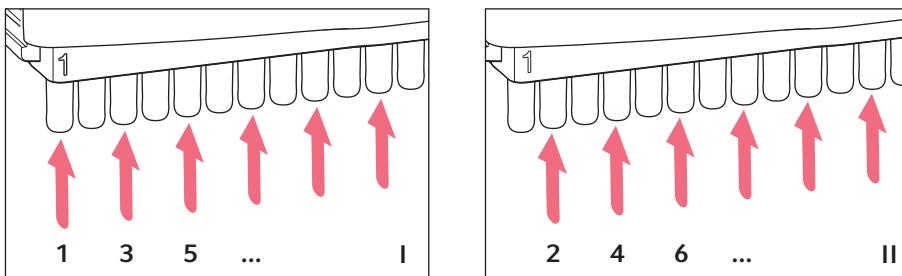


Fig. 6-6: Equipping the tip cones for test runs I and II

6.3.16 Test run I and II

Prerequisites

- A reusable box with pipette tips for test run I has been prepared
- A reusable box with pipette tips for test run II has been prepared

1. Take up pipette tips for test run I.
2. Set absorption speed and dispensing speed (see *Test conditions on p. 54*).
3. Set the operating mode (see *Test conditions on p. 54*).
4. Adjust the test volume.
5. Absorb and dispense the test liquid 5 times.
6. Immerse the test tips vertically in the test liquid.
7. Maintain immersion depth and absorb test liquid.
8. Wait until liquid aspiration is complete.
9. Slowly remove the test tips from the liquid.
10. Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.
11. Perform test dispensing procedure.
12. Determine measured values for the test volume.
13. Eject the pipette tips.
14. Take up pipette tips for test run II.
15. Absorb and dispense the test liquid 5 times.

- 16.Immerse the test tips vertically in the test liquid.
- 17.Maintain immersion depth and absorb test liquid.
- 18.Wait until liquid aspiration is complete.
- 19.Slowly remove the test tips from the liquid.
- 20.Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.
- 21.Perform test dispensing procedure.
- 22.Determine measured values for the test volume.
- 23.Determine measured values for each test volume using test runs I and II.

6.3.17 Determining measured values - electronic multi-channel pipettes with 9 mm cone distance

The electronic pipettes are only tested in one operating mode. Errors of measurement occur equally in all operating modes. A correction has an equivalent effect on all modes.

1. Set absorption speed and dispensing speed.
2. Set the operating mode.
3. Attach a test tip to each channel.
4. Adjust the test volume.
5. Absorb and dispense the test liquid 5 times.
6. Immerse the test tips vertically in the test liquid.
7. Maintain immersion depth and absorb test liquid.
8. Wait until liquid aspiration is complete.
9. Slowly remove the test tips from the liquid.
- 10.Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.
- 11.Perform test dispensing procedure.
- 12.Determine measured values for each test volume.

Performing the calibration

42 Standard Operating Procedure
English (EN)

6.3.18 Determining measured values – electronic multi-channel pipettes with adjustable cone spacing

1. Set the cone spacing to 9 mm.
2. Set absorption speed and dispensing speed.
3. Set the operating mode.
4. Attach a test tip to each channel.
5. Adjust the test volume.
6. Absorb and dispense the test liquid 5 times.
7. Immerse the test tips vertically in the test liquid.
8. Maintain immersion depth and absorb test liquid.
9. Wait until liquid aspiration is complete.
10. Slowly remove the test tips from the liquid.
11. Set the test tips against the inner wall of the weighing vessel at an angle of 30° – 45°.
12. Perform test dispensing procedure.
13. Determine measured values for each test volume.

6.3.19 Determining measured values - hybrid systems

Depending on the test tip used, a hybrid system (Varipette/Maxipettor) operates according to the air-cushion principle or the positive displacement principle. Accordingly, the measured values must be determined after the procedure for mechanical single-channel pipettes or after the procedure for mechanical multiple-dispensers.



Use the same dispensing tip as the test tip as the standard one used in your laboratory.

1. Insert the test tip.
2. Adjust the test volume.
3. Carry out the required number of presaturation steps according to the test tip used.
4. Perform test dispensing procedure.
5. Determine measured values for each test volume.

6.3.20 Determining measured values - mechanical multiple-dispensers

Eppendorf recommends the use of the 5-mL Combitips advanced, as the quality control results of a new multiple-dispenser are obtained using this Combitip. However, it is permissible to use any other Combitips advanced for calibration. Eppendorf specifies the maximum permissible errors for all Combitips advanced.

- Selector dial position 1 corresponds to 10 % of the nominal volume
 - Selector dial position 5 corresponds to 50 % of the nominal volume
 - Selector dial position 10 corresponds to 100 % of the nominal volume
1. Insert the test tip.
 2. Absorb and dispense the test liquid 1 time.
 3. Adjust the test volume.
 4. Immerse the test tips vertically in the test liquid.
 5. Maintain immersion depth and absorb test liquid.
 6. Wait until liquid aspiration is complete.
 7. Slowly remove the test tips from the liquid.
 8. Set the test tip against the inner wall of the weighing vessel at an angle of 30° – 45°.
 9. Perform test dispensing procedure.
 10. Determine measured values for each test volume.

6.3.21 Determining measured values - electronic multiple-dispensers

Eppendorf recommends the use of the 5-mL Combitips advanced, as the quality control results of a new multiple-dispenser are obtained using this Combitip. However, it is permissible to use any other Combitips advanced for calibration. Eppendorf specifies the maximum permissible errors for all Combitips advanced.

1. Set operating mode **Dis.**
2. Insert the test tip.
3. Absorb and dispense the test liquid 1 time.
4. Adjust the test volume.
5. Immerse the test tips vertically in the test liquid.
6. Maintain immersion depth and absorb test liquid.
7. Wait until liquid aspiration is complete.
8. Slowly remove the test tips from the liquid.
9. Set the test tip of the channel to test against the inner wall of the weighing vessel at an angle of 30° – 45°.
10. Perform test dispensing procedure.
11. Determine measured values for each test volume.

Performing the calibration

44 Standard Operating Procedure
English (EN)

6.3.22 Determining measured values - mechanical single stroke dispensers

1. Place a beaker on the analytical balance.
2. Adjust the test volume.
3. Absorb test liquid free of air bubbles.
4. Perform test dispensing procedure.
5. Determine measured values for each test volume.

6.3.23 Determining measured values - mechanical bottle-top burette

1. Place a beaker on the analytical balance.
2. Remove air bubbles from the dispensing system.
3. Perform test dispensing procedure.
4. Determine measured values for the test volume.

7 Evaluating the calibration

To determine the performance of dispensers, the systematic and random error are identified. A conclusion can only be drawn from the combination of both errors of measurement.

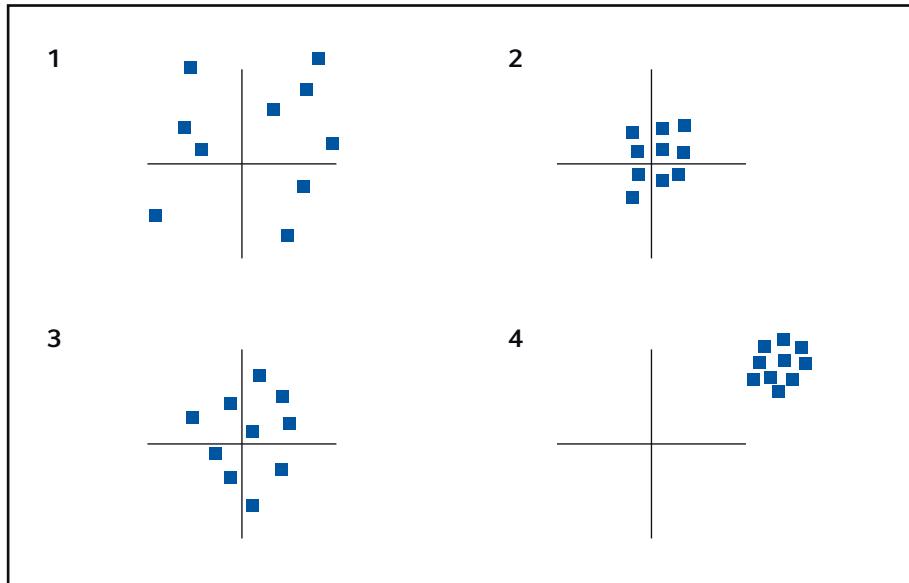


Fig. 7-1: Distribution of measured values

1 Poor precision and accuracy

2 Good precision and accuracy

3 Poor precision, good accuracy

4 Good precision, poor accuracy

The systematic and random error are calculated in the following steps:

- Convert mass value into volume
- Calculate the average value of the measured volume values
- Calculate the systematic and random error

7.1 Converting gravimetric measured values to volumes

The gravimetrically determined measured values must be converted into volume values. The correction factor Z takes into account the density of water as a function of temperature and air pressure.

$$V_i = m_i \cdot Z$$

- ▶ Multiply the measured gravimetric value by the correction factor Z.

The result is the measured volume value.

Formula symbol	Meaning
Z	Correction factor
m_i	Gravimetric measured value of all dispensing procedures
V_i	Volume value of all dispensing procedures

7.2 Correction factor Z

Tabular overview of the correction values for distilled water depending on temperature and atmospheric pressure.

Temperature in °C	Correction factor Z in µL/mg						
	800 hPa	850 hPa	900 hPa	950 hPa	1000 hPa	1013 hPa	1050 hPa
15	1.0017	1.0018	1.0019	1.0019	1.0020	1.0020	1.0020
15.5	1.0018	1.0019	1.0019	1.0020	1.0020	1.0020	1.0021
16	1.0019	1.0020	1.0020	1.0021	1.0021	1.0021	1.0022
16.5	1.0020	1.0020	1.0021	1.0021	1.0022	1.0022	1.0022
17	1.0021	1.0021	1.0022	1.0022	1.0023	1.0023	1.0023
17.5	1.0022	1.0022	1.0023	1.0023	1.0024	1.0024	1.0024
18	1.0022	1.0023	1.0023	1.0024	1.0025	1.0025	1.0025
18.5	1.0023	1.0024	1.0024	1.0025	1.0025	1.0026	1.0026
19	1.0024	1.0025	1.0025	1.0026	1.0026	1.0027	1.0027
19.5	1.0025	1.0026	1.0026	1.0027	1.0027	1.0028	1.0028
20	1.0026	1.0027	1.0027	1.0028	1.0028	1.0029	1.0029
20.5	1.0027	1.0028	1.0028	1.0029	1.0029	1.0030	1.0030
21	1.0028	1.0029	1.0029	1.0030	1.0031	1.0031	1.0031
21.5	1.0030	1.0030	1.0031	1.0031	1.0032	1.0032	1.0032
22	1.0031	1.0031	1.0032	1.0032	1.0033	1.0033	1.0033
22.5	1.0032	1.0032	1.0033	1.0033	1.0034	1.0034	1.0034
23	1.0033	1.0033	1.0034	1.0034	1.0035	1.0035	1.0036
23.5	1.0034	1.0035	1.0035	1.0036	1.0036	1.0036	1.0037
24	1.0035	1.0036	1.0036	1.0037	1.0037	1.0038	1.0038
24.5	1.0037	1.0037	1.0038	1.0038	1.0039	1.0039	1.0039
25	1.0038	1.0038	1.0039	1.0039	1.0040	1.0040	1.0040
25.5	1.0039	1.0040	1.0040	1.0041	1.0041	1.0041	1.0042
26	1.0040	1.0041	1.0041	1.0042	1.0042	1.0043	1.0043
26.5	1.0042	1.0042	1.0043	1.0043	1.0044	1.0044	1.0044
27	1.0043	1.0044	1.0044	1.0045	1.0045	1.0045	1.0046
27.5	1.0045	1.0045	1.0046	1.0046	1.0047	1.0047	1.0047
28	1.0046	1.0046	1.0047	1.0047	1.0048	1.0048	1.0048
28.5	1.0047	1.0048	1.0048	1.0049	1.0049	1.0050	1.0050
29	1.0049	1.0049	1.0050	1.0050	1.0051	1.0051	1.0051
29.5	1.0050	1.0051	1.0051	1.0052	1.0052	1.0052	1.0053
30	1.0052	1.0052	1.0053	1.0053	1.0054	1.0054	1.0054

7.3 Calculating the arithmetic mean volume value

Calculate the mean value from the volume values.

$$\bar{V} = \frac{\sum_{i=1}^n V_i}{n}$$

- ▶ Divide the sum of the volume values by the number of measurements.
Result: arithmetic mean of the volume values.

Formula symbol	Meaning
\bar{V}	Mean volume value
V_i	Volume value of all dispensing procedures
n	Number of measurements

7.4 Calculating the systematic error of measurement

The systematic measurement error is the measure of the deviation of the mean volume value from the target value of the dispensed volume.

7.4.1 Absolute systematic error of measurement

$$e_s = \bar{V} - V_s$$

- ▶ Subtract the set test volume from the mean volume value.
Result: absolute error of measurement in volume.

7.4.2 Relative systematic error of measurement

$$\eta_s = \frac{(\bar{V} - V_s) \cdot 100 \%}{V_s}$$

- ▶ Multiply the absolute error of measurement by 100 and divide it by the test volume.
Result: relative error of measurement in percent.

Formula symbol	Meaning
e_s	Absolute systematic measurement error [μL]
\bar{V}	Mean volume value
V_s	Testing volume
η_s	Relative systematic measurement error [%]

7.5 Calculating the random error of measurement

The standard deviation is a measure of the dispersion of the individual values around the mean volume value of the dispensed volume.

7.5.1 Absolute random error of measurement

$$s_r = \sqrt{\frac{\sum_{i=1}^n (V_i - \bar{V})^2}{n - 1}}$$

- ▶ Calculate the standard deviation of the volume value.
Result: absolute random error of measurement.

7.5.2 Relative random error of measurement

$$CV = \frac{100 \% \cdot s_r}{\bar{V}}$$

- ▶ Multiply the absolute error of measurement by 100 and divide it by the mean volume value.
Result: proportional random error of measurement.

Formula symbol	Meaning
s_r	Repeated standard deviation
n	Number of measurements
V_i	Testing volume
\bar{V}	Mean volume value
CV	Coefficient of variation

7.6 Test report

The calibration results and all influencing factors must be documented. The following chapters describe the contents of a test report.

7.6.1 Tester

Name	
First name	
Department	
Calibration date	

7.6.2 Dispenser

Manufacturer	
Type	
Model number	
Nominal volume	
Serial number	

7.6.3 Test tip

Manufacturer	
Designation	

7.6.4 Analytical balance

Model	
Serial number	
Last calibration	

7.6.5 Adjustment

Basis for adjustment (Ex)	
---------------------------	--

7.6.6 Test conditions

Air temperature °C	
Atmospheric pressure hPa	
Relative humidity %	

7.6.7 Test method

DIN EN ISO 8655:2022 standards series	
Laboratory regulation	
Manufacturer's specifications	
Other	

7.6.8 Measurement series

Measurement series 1

Measured values											
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	Actual value	Setpoint	Assessment
Average value \bar{V}			
Systematic error e_s			
Random error CV			
Comment			

Measurement series 2

Measured values											
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	Actual value	Setpoint	Assessment
Average value \bar{V}			
Systematic error e_s			
Random error CV			
Comment			

Measurement series 3

Measured values										
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	Actual value	Setpoint	Assessment
Average value \bar{V}			
Systematic error e_s			
Random error CV			
Comment			

7.6.9 Cleaning

Name	
First name	
Department	
Date	
Comment	

7.6.10 Service

Name	
First name	
Department	
Date	
Replaced parts	
Comment	

8 Permissible errors of measurement



The tables with the errors of measurement are sorted alphabetically by product name in this chapter.

8.1 Test conditions

Test conditions and test analysis in accordance with DIN EN ISO 8655: Testing with tested analytical balance with evaporation protection.



The three testing volume per tip (10 %, 50 %, 100 % of the nominal volume) are in accordance with the specifications of DIN EN ISO 8655. For testing of the systematic and random measurement error in accordance with the standard, the testing must be carried out with these three testing volumes. The smallest adjustable volume serves to provide additional information.

- Number of determinations per volume: 10
- Water according to ISO 3696:1991-06
- Testing at 20 °C (± 3 °C) – 27°C (± 3 °C)
Maximum temperature variation during measurement ± 0.5 °C
- Dispensing onto the tube inner wall

8.1.1 Multipette E3/E3x

- Operating mode: **Dis**
- Test with a completely filled Combitips advanced
- Speed level: 5

8.1.2 Multipette stream/Xstream

- Operating mode: **Dis**
- Speed level: 7

8.1.3 Xplorer/Xplorer plus

- Operating mode: Standard pipetting (**Pip**)
- Speed level: 5

8.2 Biomaster – Error of measurement

Model	Test tip Mastertip	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
1 µL – 20 µL  light gray	20 µL light gray 52 mm	2 µL	6.0	0.12	4.0	0.08
		10 µL	3.0	0.3	1.5	0.15
		20 µL	2.0	0.4	0.8	0.16

8.3 Multipette E3/E3x – Repeater E3/E3x - error of measurement

Test tip Combitips advanced	Volume range	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.1 mL <input type="checkbox"/> white	1 µL – 100 µL	1 µL	11	0.11	14	0.14
		10 µL	1.6	0.16	2.5	0.25
		50 µL	1	0.5	1.5	0.75
		100 µL	1	1	0.5	0.5
0.2 mL <input type="checkbox"/> light blue	2 µL – 200 µL	2 µL	4	0.08	5.5	0.11
		20 µL	1.3	0.26	1.5	0.3
		100 µL	1	1	1	1
		200 µL	1	2	0.5	1
0.5 mL <input type="checkbox"/> violet	5 µL – 500 µL	5 µL	3	0.15	6	0.3
		50 µL	0.9	0.45	0.8	0.4
		250 µL	0.9	2.25	0.5	1.25
		500 µL	0.9	4.5	0.3	1.5
1 mL <input type="checkbox"/> yellow	10 µL – 1000 µL	10 µL	3.5	0.35	7	0.7
		100 µL	0.9	0.9	0.55	0.55
		500 µL	0.6	3	0.3	1.5
		1000 µL	0.6	6	0.2	2
2.5 mL <input type="checkbox"/> green	25 µL – 2500 µL	25 µL	2	0.5	3.5	0.875
		250 µL	0.8	2	0.45	1.125
		1250 µL	0.5	6.25	0.3	3.75
		2500 µL	0.5	12.5	0.15	3.75
5 mL <input type="checkbox"/> blue	50 µL – 5000 µL	50 µL	2.5	1.25	6	3
		500 µL	0.8	4	0.35	1.75
		2500 µL	0.5	12.5	0.25	6.25
		5000 µL	0.5	25	0.15	7.5
10 mL <input type="checkbox"/> orange	0.1 mL – 10 mL	0.1mL	1.5	1.5	3.5	3.5
		1 mL	0.5	5	0.25	2.5
		5 mL	0.4	20	0.25	12.5
		10 mL	0.4	40	0.15	15

Test tip Combitips advanced	Volume range	Testing volume	Measurement error			
			systematic		random	
			± %	± μL	%	μL
25 mL ■ red	0.25 mL – 25 mL	0.25 mL	2.5	6.25	3	7.5
		2.5 mL	0.3	7.5	0.35	8.75
		12.5 mL	0.3	37.5	0.25	31.25
		25 mL	0.3	75	0.15	37.5
50 mL ■ light gray	0.5 mL – 50 mL	0.5 mL	2	10	3	15
		5 mL	0.3	15	0.5	25
		25 mL	0.3	75	0.2	50
		50 mL	0.3	150	0.15	75

8.4 Multipette M4 – Repeater M4 - error of measurement

Test tip Combitips advanced	Dispensing volume	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.1 mL <input type="checkbox"/> white	1 µL – 20 µL	1 µL	8	0.08	13	0.13
		2 µL	1.6	0.032	3	0.06
		10 µL	1.2	0.12	2.4	0.24
		20 µL	1	0.2	2	0.4
0.2 mL <input type="checkbox"/> light blue	2 µL – 40 µL	2 µL	6	0.12	8	0.16
		4 µL	1.3	0.052	2	0.08
		20 µL	0.8	0.16	1.5	0.3
		40 µL	0.8	0.32	1.5	0.6
0.5 mL <input type="checkbox"/> violet	5 µL – 100 µL	5 µL	4	0.2	8	0.4
		10 µL	0.9	0.09	1.5	0.15
		50 µL	0.8	0.4	0.8	0.4
		100 µL	0.8	0.8	0.6	0.6
1 mL <input type="checkbox"/> yellow	10 µL – 200 µL	10 µL	4	0.4	8	0.8
		20 µL	0.9	0.18	0.9	0.18
		100 µL	0.6	0.6	0.6	0.6
		200 µL	0.6	1.2	0.4	0.8
2.5 mL <input type="checkbox"/> green	25 µL – 500 µL	25 µL	4	1	8	2
		50 µL	0.8	0.4	0.8	0.4
		250 µL	0.6	1.5	0.6	1.5
		500 µL	0.5	2.5	0.3	1.5
5 mL <input type="checkbox"/> blue	50 µL – 1000 µL	50 µL	3	1.5	5	2.5
		100 µL	0.6	0.6	0.6	0.6
		500 µL	0.5	2.5	0.5	2.5
		1000 µL	0.5	5	0.25	2.5
10 mL <input type="checkbox"/> orange	0.1 mL – 2 mL	0.1 mL	3	3	4	4
		0.2 mL	0.5	1	0.6	1.2
		1 mL	0.5	5	0.4	4
		2 mL	0.5	10	0.25	5

Test tip Combitips advanced	Dispensing volume	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
25 mL ■ red	0.25 mL – 5 mL	0.25 mL	3	7.5	3	7.5
		0.5 mL	0.4	2	0.6	3
		2.5 mL	0.3	7.5	0.5	12.5
		5 mL	0.3	15	0.25	12.5
50 mL ■ light gray	0.5 mL – 10mL	0.5 mL	6	30	10	50
		1 mL	0.3	3	0.5	5
		5 mL	0.3	15	0.5	25
		10 mL	0.3	30	0.25	25

8.5 Multipette plus – Repeater plus - error of measurement

Test tip Combitip advanced	Volume range	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.1 mL <input type="checkbox"/> white	1 µL – 20 µL	2 µL	1.6	0.032	3.0	0.06
		10 µL	1.2	0.12	2.4	0.24
		20 µL	1.0	0.2	2.0	0.4
0.2 mL <input type="checkbox"/> light blue	2 µL – 40 µL	4 µL	1.3	0.052	2.0	0.08
		20 µL	0.8	0.16	1.5	0.3
		40 µL	0.8	0.32	1.5	0.6
0.5 mL <input checked="" type="checkbox"/> violet	5 µL – 100 µL	10 µL	0.9	0.09	1.5	0.15
		50 µL	0.8	0.4	0.8	0.4
		100 µL	0.8	0.8	0.6	0.6
1 mL <input type="checkbox"/> yellow	10 µL – 200 µL	20 µL	0.9	0.18	0.9	0.18
		100 µL	0.6	0.6	0.6	0.6
		200 µL	0.6	1.2	0.4	0.8
2.5 mL <input type="checkbox"/> green	25 µL – 500 µL	50 µL	0.8	0.4	0.8	0.4
		250 µL	0.6	1.5	0.6	1.5
		500 µL	0.5	2.5	0.3	1.5
5 mL <input type="checkbox"/> blue	50 µL – 1000 µL	100 µL	0.6	0.6	0.6	0.6
		500 µL	0.5	2.5	0.5	2.5
		1000 µL	0.5	5.0	0.25	2.5
10 mL <input type="checkbox"/> orange	0.1 mL – 2 mL	0.2 mL	0.5	1.0	0.6	1.2
		1 mL	0.5	5	0.4	4
		2 mL	0.5	10	0.25	5.0
25 mL <input type="checkbox"/> red	0.25 mL – 5 mL	0.5 mL	0.4	2.0	0.6	3.0
		2.5 mL	0.3	7.5	0.5	12.5
		5 mL	0.3	15	0.25	12.5
50 mL <input type="checkbox"/> light gray	0.5 mL – 10 mL	1 mL	0.3	3.0	0.5	5.0
		5 mL	0.3	15	0.5	25
		10 mL	0.3	30	0.25	25

8.6 Multipette/Repeater stream/Xstream - error of measurement

Test tip Combitip advanced	Volume range	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.1 mL <input type="checkbox"/> white	1 µL – 100 µL	10 µL	1.6	0.16	2.5	0.25
		50 µL	1.0	0.5	1.5	0.75
		100 µL	1.0	1.0	0.5	0.5
0.2 mL <input type="checkbox"/> light blue	2 µL – 200 µL	20 µL	1.3	0.26	1	0.2
		100 µL	1.0	1.0	1.0	1.0
		200 µL	1.0	2.0	0.5	1.0
0.5 mL <input checked="" type="checkbox"/> violet	5 µL – 500 µL	50 µL	0.9	0.45	0.8	0.4
		250 µL	0.9	2.25	0.5	1.25
		500 µL	0.9	4.5	0.3	1.5
1 mL <input type="checkbox"/> yellow	10 µL – 1000 µL	100 µL	0.9	0.9	0.55	0.55
		500 µL	0.6	3.0	0.3	1.5
		1000 µL	0.6	6.0	0.2	2.00
2.5 mL <input type="checkbox"/> green	25 µL – 2500 µL	250 µL	0.8	2.0	0.45	1.125
		1250 µL	0.5	6.25	0.3	3.75
		2500 µL	0.5	12.5	0.15	3.75
5 mL <input type="checkbox"/> blue	50 µL – 5000 µL	500 µL	0.8	4.0	0.35	1.75
		2500 µL	0.5	12.5	0.25	6.25
		5000 µL	0.5	25	0.15	7.50
10 mL <input type="checkbox"/> orange	0.1 mL – 10 mL	1 mL	0.5	5	0.25	2.5
		5 mL	0.4	20	0.25	12.5
		10 mL	0.4	40	0.15	15
25 mL <input type="checkbox"/> red	0.25 mL – 25 mL	2.5 mL	0.3	7.5	0.35	8.8
		12.5 mL	0.3	37.5	0.25	31.3
		25 mL	0.3	75	0.15	37.5
50 mL <input type="checkbox"/> light gray	0.5 mL – 50 mL	5 mL	0.3	15	0.5	25
		25 mL	0.3	75	0.20	50
		50 mL	0.3	150	0.15	75

8.7 Reference 2 - error of measurement

8.7.1 Reference 2 – single-channel pipettes with fixed volume

Model	Test tip epT.I.P.S.	Measurement error			
		systematic		random	
		± %	± µL	%	µL
1 µL █ dark gray	0.1 µL – 10 µL █ dark gray 34 mm	2.5	0.025	1.8	0.018
2 µL █ dark gray		2.0	0.04	1.2	0.024
5 µL █ medium gray	0.1 µL – 20 µL █ medium gray 40 mm	1.2	0.06	0.6	0.03
10 µL █ medium gray		1.0	0.1	0.5	0.05
20 µL █ light gray	0.5 µL – 20 µL L █ light gray 46 mm	0.8	0.16	0.3	0.06
10 µL █ yellow	2 µL – 200 µL █ yellow 53 mm	1.2	0.12	0.6	0.06
20 µL █ yellow		1.0	0.2	0.3	0.06
25 µL █ yellow		1.0	0.25	0.3	0.075
50 µL █ yellow		0.7	0.35	0.3	0.15
100 µL █ yellow		0.6	0.6	0.2	0.2
200 µL █ yellow		0.6	1.2	0.2	0.4
200 µL █ blue	50 µL – 1000 µL █ blue 71 mm	0.6	1.2	0.2	0.4
250 µL █ blue		0.6	1.5	0.2	0.5
500 µL █ blue		0.6	3.0	0.2	1.0
1000 µL █ blue		0.6	6.0	0.2	2.0

Model	Test tip epT.I.P.S.	Measurement error			
		systematic		random	
		± %	± µL	%	µL
2.0 mL ■ red	0.25 mL – 2.5 mL ■ red 115 mm	0.6	12	0.2	4
		0.6	15	0.2	5

8.7.2 Reference 2 - single-channel pipettes with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.1 µL – 2.5 µL ■ dark gray	0.1 µL – 10 µL ■ dark gray 34 mm	0.1 µL	48.0	0.048	12.0	0.012
		0.25 µL	12.0	0.03	6.0	0.015
		1.25 µL	2.5	0.031	1.5	0.019
		2.5 µL	1.4	0.035	0.7	0.018
0.5 µL – 10 µL ■ medium gray	0.1 µL – 20 µL ■ medium gray 40 mm	0.5 µL	8.0	0.04	5.0	0.025
		1 µL	2.5	0.025	1.8	0.018
		5 µL	1.5	0.075	0.8	0.04
		10 µL	1.0	0.10	0.4	0.04
2 µL – 20 µL ■ light gray	0.5 µL – 20 µL ■ light gray 46 mm	2 µL	3.0	0.06	1.5	0.03
		10 µL	1.0	0.10	0.6	0.06
		20 µL	0.8	0.16	0.3	0.06
2 µL – 20 µL ■ yellow	2 µL – 200 µL ■ yellow 53 mm	2 µL	5.0	0.10	1.5	0.03
		10 µL	1.2	0.12	0.6	0.06
		20 µL	1.0	0.2	0.3	0.06
10 µL – 100 µL ■ yellow	2 µL – 200 µL ■ yellow 53 mm	10 µL	3.0	0.3	0.7	0.07
		50 µL	1.0	0.5	0.3	0.15
		100 µL	0.8	0.8	0.2	0.2
20 µL – 200 µL ■ yellow	2 µL – 200 µL ■ yellow 53 mm	20 µL	2.5	0.5	0.7	0.14
		100 µL	1.0	1.0	0.3	0.3
		200 µL	0.6	1.2	0.2	0.4

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
30 µL – 300 µL  orange	20 µL – 300 µL  orange 55 mm	30 µL	2.5	0.75	0.7	0.21
		150 µL	1.0	1.5	0.3	0.45
		300 µL	0.6	1.8	0.2	0.6
100 µL – 1000 µL  blue	50 µL – 1000 µL  blue 71 mm	100 µL	3.0	3.0	0.6	0.6
		500 µL	1.0	5.0	0.2	1.0
		1000 µL	0.6	6.0	0.2	2.0
0.25 mL – 2.5 mL  red	0.25 mL – 2.5 mL  red 115 mm	0.25 mL	4.8	12	1.2	3
		1.25 mL	0.8	10	0.2	2.5
		2.5 mL	0.6	15	0.2	5
0.5 mL – 5 mL  violet	0.1 mL – 5 mL  violet 120 mm	0.5 mL	2.4	12	0.6	3
		2.5 mL	1.2	30	0.25	6.25
		5.0 mL	0.6	30	0.15	7.5
1 mL – 10 mL  turquoise	0.5 mL – 10 mL  turquoise 165 mm	1.0 mL	3.0	30	0.6	6
		5.0 mL	0.8	40	0.2	10
		10.0 mL	0.6	60	0.15	15

8.7.3 Reference 2 - multi-channel pipettes with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.5 µL – 10 µL  medium gray	0.1 µL – 20 µL  medium gray 40 mm	0.5 µL	12.0	0.06	8.0	0.04
		1 µL	8.0	0.08	5.0	0.05
		5 µL	4.0	0.2	2.0	0.1
		10 µL	2.0	0.2	1.0	0.1
10 µL – 100 µL  yellow	2 µL – 200 µL  yellow 53 mm	10 µL	3.0	0.3	2.0	0.2
		50 µL	1.0	0.5	0.8	0.4
		100 µL	0.8	0.8	0.3	0.3
30 µL – 300 µL  orange	20 µL – 300 µL  orange 55 mm	30 µL	3.0	0.9	1.0	0.3
		150 µL	1.0	1.5	0.5	0.75
		300 µL	0.6	1.8	0.3	0.9

8.8 Research plus - error of measurement

8.8.1 Research plus – single-channel pipettes with fixed volume

Model	Test tip epT.I.P.S.	Measurement error			
		systematic		random	
		± %	± µL	%	µL
10 µL █ medium gray	0.1 µL – 20 µL █ medium gray 40 mm	1.2	0.12	0.6	0.06
20 µL █ light gray	0.5 µL – 20 µL L █ light gray 46 mm	0.8	0.16	0.3	0.06
10 µL █ yellow	2 µL – 200 µL █ yellow 53 mm	1.2	0.12	0.6	0.06
20 µL █ yellow		1.0	0.2	0.3	0.06
25 µL █ yellow		1.0	0.25	0.3	0.08
50 µL █ yellow		0.7	0.35	0.3	0.15
100 µL █ yellow		0.6	0.6	0.2	0.2
200 µL █ yellow		0.6	1.2	0.2	0.4
200 µL █ blue		0.6	1.2	0.2	0.4
250 µL █ blue	50 µL – 1000 µL █ blue 71 mm	0.6	1.5	0.2	0.5
500 µL █ blue		0.6	3.0	0.2	1.0
1000 µL █ blue		0.6	6.0	0.2	2.0

8.8.2 Research plus – single-channel pipettes with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.1 µL – 2.5 µL 	0.1 µL – 10 µL  34 mm	0.1 µL	48	0.048	12	0.012
		0.25 µL	12	0.03	6.0	0.015
		1.25 µL	2.5	0.031	1.5	0.019
		2.5 µL	1.4	0.035	0.7	0.018
0.5 µL – 10 µL 	0.1 µL – 20 µL  40 mm	0.5 µL	8.0	0.04	5.0	0.025
		1 µL	2.5	0.025	1.8	0.018
		5 µL	1.5	0.075	0.8	0.04
		10 µL	1.0	0.1	0.4	0.04
2 µL – 20 µL 	0.5 µL – 20 µL L  46 mm	2 µL	5.0	0.1	1.5	0.03
		10 µL	1.2	0.12	0.6	0.06
		20 µL	1.0	0.2	0.3	0.06
2 µL – 20 µL 	2 µL – 200 µL  53 mm	2 µL	5.0	0.1	1.5	0.03
		10 µL	1.2	0.12	0.6	0.06
		20 µL	1.0	0.2	0.3	0.06
10 µL – 100 µL 	2 µL – 200 µL  53 mm	10 µL	3.0	0.3	1.0	0.1
		50 µL	1.0	0.5	0.3	0.15
		100 µL	0.8	0.8	0.2	0.2
20 µL – 200 µL 	2 µL – 200 µL  53 mm	20 µL	2.5	0.5	0.7	0.14
		100 µL	1.0	1.0	0.3	0.3
		200 µL	0.6	1.2	0.2	0.4
30 µL – 300 µL 	20 µL – 300 µL  55 mm	30 µL	2.5	0.75	0.7	0.21
		150 µL	1.0	1.5	0.3	0.45
		300 µL	0.6	1.8	0.2	0.6
100 µL – 1000 µL 	50 µL – 1000 µL  71 mm	100 µL	3.0	3.0	0.6	0.6
		500 µL	1.0	5.0	0.2	1.0
		1000 µL	0.6	6.0	0.2	2.0
0.25 mL – 2.5 mL 	0.25 mL – 2.5 mL  115 mm	0.25 mL	4.8	12	1.2	3
		1.25 mL	0.8	10	0.2	2.5
		2.5 mL	0.6	15	0.2	5

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.5 mL – 5 mL ■ violet	0.1 mL – 5 mL ■ violet 120 mm	0.5 mL	2.4	12	0.6	3
		2.5 mL	1.2	30	0.25	6.25
		5.0 mL	0.6	30	0.15	7.5
1 mL – 10 mL ■ turquoise	0.5 mL – 10 mL ■ turquoise 165 mm	1.0 mL	3.0	30	0.6	6
		5.0 mL	0.8	40	0.2	10
		10.0 mL	0.6	60	0.15	15

8.8.3 Research plus - multi-channel pipettes with fixed cone spacing

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.5 µL – 10 µL ■ medium gray 8/12-channel	0.1 µL – 20 µL ■ medium gray 40 mm	0.5 µL	12	0.06	8.0	0.04
		1 µL	8.0	0.08	5.0	0.05
		5 µL	4.0	0.2	2.0	0.1
		10 µL	2.0	0.2	1.0	0.1
1 µL – 20 µL ■ light pink 16/24-channel	1 µL – 20 µL ■ light pink 42 mm	1 µL	12	0.12	8	0.08
		2 µL	8	0.16	5	0.1
		10 µL	4	0.4	2	0.2
		20 µL	2	0.4	1	0.2
5 µL – 100 µL ■ light yellow 16/24-channel	5 µL – 100 µL ■ light yellow 53 mm	5 µL	6	0.3	4	0.2
		10 µL	3	0.3	2	0.2
		50 µL	1.2	0.6	0.8	0.4
		100 µL	1	1	0.6	0.6
10 µL – 100 µL ■ yellow 8/12-channel	2 µL – 200 µL ■ yellow 53 mm	10 µL	3.0	0.3	2.0	0.2
		50 µL	1.0	0.5	0.8	0.4
		100 µL	0.8	0.8	0.3	0.3
30 µL – 300 µL ■ orange 8/12-channel	20 µL – 300 µL ■ orange 55 mm	30 µL	3.0	0.9	1.0	0.3
		150 µL	1.0	1.5	0.5	0.75
		300 µL	0.6	1.8	0.3	0.9

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
50 µL – 1200 µL  dark green 8/12-channel	50 µL – 1250 µL L  dark green 103 mm	120 µL	6.0	7.2	0.9	1.08
		600 µL	2.7	16.2	0.4	2.4
		1200 µL	1.2	14.4	0.3	3.6

8.8.4 Research plus - multi-channel pipettes with adjustable cone spacing

Model	Test tip epT.I.P.S. epT.I.P.S. 384	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
1 µL – 20 µL  light pink 8/12-channel	1 µL – 20 µL  light pink 42 mm	1 µL	15	0.15	8	0.08
		2 µL	10	0.2	5	0.1
		10 µL	4	0.4	2	0.2
		20 µL	2	0.4	1	0.2
5 µL – 100 µL  light yellow 8/12-channel	5 µL – 100 µL  light yellow 53 mm	5 µL	6	0.3	4	0.2
		10 µL	3	0.3	2	0.2
		50 µL	1.2	0.6	0.8	0.4
		100 µL	1	1	0.6	0.6
30 µL – 300 µL  orange 4/6/8-channel	20 µL – 300 µL  orange 55 mm	30 µL	3.7	1.1	1.8	0.5
		150 µL	1	1.5	0.6	0.9
		300 µL	0.7	2.1	0.6	1.8
120 µL – 1200 µL  dark green 4/6/8-channel	50 µL – 1250 µL L  dark green 103 mm	120 µL	6	7.2	1.3	1.6
		600 µL	2.7	16.2	0.4	2.4
		1200 µL	1.2	14.4	0.3	3.6

8.9 Top Buret M/H - error of measurement**8.9.1 Top Buret M**

Model M	Testing volume	Measurement error			
		systematic		random	
		± %	± mL	%	mL
0.01 mL – 999.9 mL	2.5 mL	2.0	0.05	1.0	0.025
	12.5 mL	0.4	0.05	0.2	0.025
	25 mL	0.2	0.05	0.1	0.025

8.9.2 Top Buret H

Model H	Testing volume	Measurement error			
		systematic		random	
		± %	± mL	%	mL
0.01 mL – 999.9 mL	5 mL	2.0	0.1	1.0	0.05
	25 mL	0.4	0.1	0.2	0.05
	50 mL	0.2	0.1	0.1	0.05

70 Permissible errors of measurement

Standard Operating Procedure English (EN)

8.10 Varipette - error of measurement

Model	Test tip	Testing volume	Measurement error			
			systematic		random	
			± %	± mL	%	mL
2.5 mL – 10 mL	Varitips S-System	2.5 mL	1.0	0.025	0.2	0.005
		5 mL	0.4	0.02	0.2	0.01
		10 mL	0.3	0.03	0.2	0.02
1 mL – 10 mL	Varitips P	1 mL	0.6	0.006	0.3	0.003
		5 mL	0.5	0.025	0.15	0.0075
		10 mL	0.3	0.03	0.1	0.01

8.10.1 Maxipettor - error of measurement

Model	Test tip	Testing volume	Measurement error			
			systematic		random	
			± %	± mL	%	mL
2.5 mL – 10 mL	Maxitips S-System	2.5 mL	1.0	0.025	0.2	0.005
		5 mL	0.4	0.02	0.2	0.01
		10 mL	0.3	0.03	0.2	0.02
1 mL – 10 mL	Maxitips P	1 mL	0.6	0.006	0.3	0.003
		5 mL	0.5	0.025	0.15	0.0075
		10 mL	0.3	0.03	0.1	0.01

8.11 Varispenser/Varispenser plus - error of measurement

Model	Testing volume	Measurement error			
		systematic		random	
		± %	± mL	%	mL
0.5 mL – 2.5 mL	0.5 mL	6.0	0.015	1.0	0.0025
	1.25 mL	1.2	0.015	0.2	0.0025
	2.50 mL	0.6	0.015	0.1	0.0025
1 mL – 5 mL	1.00 mL	2.5	0.025	0.5	0.0050
	2.50 mL	1.0	0.025	0.2	0.0050
	5.00 mL	0.5	0.025	0.1	0.0050
2 mL – 10 mL	2.00 mL	2.5	0.050	0.5	0.0100
	5.00 mL	1.0	0.050	0.2	0.0100
	10.00 mL	0.5	0.050	0.1	0.0100
5 mL – 25 mL	5.00 mL	2.5	0.125	0.5	0.0250
	12.50 mL	1.0	0.125	0.2	0.0250
	25.00 mL	0.5	0.125	0.1	0.0250
10 mL – 50 mL	10.00 mL	2.5	0.250	0.5	0.0500
	25.00 mL	1.0	0.250	0.2	0.0500
	50.00 mL	0.5	0.250	0.1	0.0500
20 mL – 100 mL	20.00 mL	2.5	0.500	0.5	0.1000
	50.00 mL	1.0	0.500	0.2	0.1000
	100.00 mL	0.5	0.500	0.1	0.1000

Permissible errors of measurement

Standard Operating Procedure

English (EN)

8.12 Varispenser 2/Varispenser 2x – errors of measurement

Model	Testing volume	Measurement error			
		systematic		random	
		± %	± µL	%	µL
0.2 mL – 2 mL	0.2 mL	5	10	1	2
	1 mL	1	10	0.2	2
	2 mL	0.5	10	0.1	2
0.5 mL – 5 mL	0.5 mL	5	25	1	5
	2.5 mL	1	25	0.2	5
	5 mL	0.5	25	0.1	5
1 mL – 10 mL	1 mL	5	50	1	10
	5 mL	1	50	0.2	10
	10 mL	0.5	50	0.1	10
2.5 mL – 25 mL	2.5 mL	5	125	1	25
	12.5 mL	1	125	0.2	25
	25 mL	0.5	125	0.1	25
5 mL – 50mL	5 mL	5	250	1	50
	25 mL	1	250	0.2	50
	50 mL	0.5	250	0.1	50
10 mL – 100 mL	10 mL	5	500	1	100
	50 mL	1	500	0.2	100
	100 mL	0.5	500	0.1	100

8.13 Xplorer/Xplorer plus - error of measurement

8.13.1 Xplorer/Xplorer plus - single-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.5 µL – 10 µL  medium gray	0.1 µL – 20 µL  medium gray 40 mm	0.5 µL	6	0.03	3	0.015
		1 µL	2.5	0.025	1.8	0.018
		5 µL	1.5	0.075	0.8	0.04
		10 µL	1.0	0.1	0.4	0.04
1 µL – 20 µL  light gray	0.5 µL – 20 µL L  light gray 46 mm	1 µL	10	0.1	3	0.03
		2 µL	5.0	0.1	1.5	0.03
		10 µL	1.2	0.12	0.6	0.06
		20 µL	1.0	0.2	0.3	0.06
5 µL – 100 µL  yellow	2 µL – 200 µL  yellow 53 mm	5 µL	4	0.2	2	0.1
		10 µL	2.0	0.2	1.0	0.1
		50 µL	1.0	0.5	0.3	0.15
		100 µL	0.8	0.8	0.2	0.2
10 µL – 200 µL  yellow	2 µL – 200 µL  yellow 53 mm	10 µL	5	0.5	1.4	0.14
		20 µL	2.5	0.5	0.7	0.14
		100 µL	1.0	1.0	0.3	0.3
		200 µL	0.6	1.2	0.2	0.4
15 µL – 300 µL  orange	20 µL – 300 µL  orange 55 mm	15 µL	5	0.75	1.4	0.21
		30 µL	2.5	0.75	0.7	0.21
		150 µL	1.0	1.5	0.3	0.45
		300 µL	0.6	1.8	0.2	0.6
50 µL – 1000 µL  blue	50 µL – 1000 µL  blue 71 mm	50 µL	6	3	1	0.5
		100 µL	3.0	3.0	0.6	0.6
		500 µL	1.0	5.0	0.2	1
		1000 µL	0.6	6.0	0.2	2
0.125 mL – 2.5 mL  red	0.25 mL – 2.5 mL  red 115 mm	0.125 mL	5	6.25	1.4	1.75
		0.25 mL	4.8	12	1.2	3
		1.25 mL	0.8	10	0.2	2.5
		2.5 mL	0.6	15	0.2	5

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.2 mL – 5 mL ■ violet	0.1 mL – 5 mL ■ violet 120 mm	0.25 mL	4.8	12	1.2	3
		0.5 mL	3.0	15.0	0.6	3
		2.5 mL	1.2	30.0	0.25	6.25
		5 mL	0.6	30.0	0.15	7.5
0.5 mL – 10 mL ■ turquoise	0.5 mL – 10 mL ■ turquoise 165 mm	0.5 mL	6	30	1.2	6
		1 mL	3.0	30.0	0.60	6.0
		5 mL	0.8	40.0	0.20	10.0
		10 mL	0.6	60.0	0.15	15.0

8.13.2 Xplorer/Xplorer plus - multi-channel pipettes with fixed cone spacing

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
0.5 µL – 10 µL ■ medium gray 8/12-channel	0.1 µL – 20 µL ■ medium gray 40 mm	0.5 µL	10	0.05	6	0.03
		1 µL	5.0	0.05	3.0	0.03
		5 µL	3.0	0.15	1.5	0.075
		10 µL	2.0	0.2	0.8	0.08
1 µL – 20 µL ■ light pink 16/24-channel	1 µL – 20 µL ■ light pink 42 mm	1 µL	12	0.12	8	0.08
		2 µL	8	0.16	5	0.1
		10 µL	4	0.4	2	0.2
		20 µL	2	0.4	1	0.2
5 µL – 100 µL ■ yellow 8/12-channel	2 µL – 200 µL ■ yellow 53 mm	5 µL	6	0.3	4	0.2
		10 µL	2.0	0.2	2.0	0.2
		50 µL	1.0	0.5	0.8	0.4
		100 µL	0.8	0.8	0.25	0.25
5 µL – 100 µL ■ light yellow 16/24-channel	5 µL – 100 µL ■ light yellow 53 mm	5 µL	6	0.3	4	0.2
		10 µL	3	0.3	2	0.2
		50 µL	1.2	0.6	0.8	0.4
		100 µL	1	1	0.6	0.6

Model	Test tip epT.I.P.S.	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
15 µL – 300 µL  orange 8/12-channel	20 µL – 300 µL  orange 55 mm	15 µL	6	0.9	2	0.3
		30 µL	2.5	0.75	1.0	0.3
		150 µL	1.0	1.5	0.5	0.75
		300 µL	0.6	1.8	0.25	0.75
50 µL – 1200 µL  green 8/12-channel	50 µL – 1250 µL  green 76 mm	50 µL	8	4	1.2	0.6
		120 µL	6.0	7.2	0.9	1.08
		600 µL	2.7	16.2	0.4	2.4
		1200 µL	1.2	14.4	0.3	3.6

8.13.3 Xplorer/Xplorer plus - multi-channel pipettes with adjustable cone spacing

Model	Test tip epT.I.P.S. epT.I.P.S. 384	Testing volume	Measurement error			
			systematic		random	
			± %	± µL	%	µL
1 µL – 20 µL  light pink 8/12 channel	1 µL – 20 µL  light pink 42 mm	1 µL	12	0.12	8	0.08
		2 µL	8	0.16	5	0.1
		10 µL	4	0.4	2	0.2
		20 µL	2	0.4	1	0.2
5 µL – 100 µL  light yellow 8/12 channel	5 µL – 100 µL  light yellow 53 mm	5 µL	6	0.3	4	0.2
		10 µL	3	0.3	2	0.2
		50 µL	1.2	0.6	0.8	0.4
		100 µL	1	1	0.6	0.6
15 µL – 300 µL  orange 4/6/8-channel	20 µL – 300 µL  orange 55 mm	15 µL	6	0.9	2	0.3
		30 µL	3	0.9	1	0.3
		150 µL	1	1.5	0.5	0.75
		300 µL	0.6	1.8	0.25	0.75
50 µL – 1200 µL  green 4/6/8-channel	50 µL – 1250 µL  green 76 mm	50 µL	8	4	1.2	0.6
		120 µL	6	7.2	0.9	1.08
		600 µL	2.7	16.2	0.4	2.4
		1200 µL	1.2	14.4	0.3	3.6

8.14 Maximum permissible errors according to DIN EN ISO 8655

The maximum permissible errors always refer to the entire pipette and pipette tip system. Dispensing volumes smaller than 10 % of the nominal volume are not considered.

8.14.1 Air-cushion pipettes with fixed and variable volume

- Reference 2
- Research plus
- Xplorer
- Xplorer plus

Tab. 8-1: Single-channel pipette

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 maximum permissible errors	
		systematic	random
		± %	%
1 µL – 3 µL	10	25	20
	50	5.0	4.0
	100	2.5	2.0
> 3 µL – 5 µL	10	25	15
	50	5.0	3.0
	100	2.5	1.5
> 5 µL – 10 µL	10	12	8.0
	50	2.4	1.6
	100	1.2	0.8
> 10 µL – 50 µL	10	10	5.0
	50	2.0	1.0
	100	1.0	0.5
> 50 µL – 5000 µL	10	8.0	3.0
	50	1.6	0.60
	100	0.80	0.30
> 5000 µL – 20000 µL	10	6.0	3.0
	50	1.2	0.60
	100	0.60	0.30

Tab. 8-2: Multi-channel pipette

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 maximum permissible errors	
		systematic	random
		± %	%
2 µL	10	25	25
	50	16	16
	100	8.0	8.0
> 2 µL – 5 µL	10	25	25
	50	10	6.0
	100	5.0	3.0
> 5 µL – 10 µL	10	24	16
	50	4.8	3.2
	100	2.4	1.6
> 10 µL – 20 µL	10	20	10
	50	4.0	2.0
	100	2.0	1.0
> 20 µL – 50 µL	10	20	8.0
	50	4.0	1.6
	100	2.0	0.80
> 50 µL – 2000 µL	10	16	6.0
	50	3.2	1.2
	100	1.6	0.60

8.14.2 Positive displacement pipettes

- Biomaster
- Varipette/Maxipettor

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 maximum permissible errors	
		systematic	random
		± %	%
5 µL	10	25	15
	50	5.0	3.0
	100	2.5	1.5
> 5µL – 10 µL	10	20	10
	50	4.0	2.0
	100	2.0	1.0
> 10µL – 20 µL	10	20	8.0
	50	4.0	1.6
	100	2.0	0.80
> 20µL – 100 µL	10	14	6.0
	50	2.8	1.2
	100	1.4	0.60
> 100µL – 1000 µL	10	12	4.0
	50	2.4	0.80
	100	1.2	0.40

8.14.3 Multi-dispenser

- Multipette plus
- Multipette/Repeater E3
- Multipette/Repeater E3x
- Multipette/Repeater M4
- Multipette stream
- Multipette Xstream

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 maximum permissible errors	
		systematic	random
		± %	%
0.001 mL – 0.002 mL	10	25	25
	50	10	10
	100	5.0	5.0
> 0.002 mL – 0.003 mL	10	25	25
	50	5.0	7.0
	100	2.5	3.5
> 0.003 mL – 0.01 mL	10	20	25
	50	4.0	5.0
	100	2.0	2.5
> 0.01 mL – 0.02 mL	10	15	20
	50	3.0	4.0
	100	1.5	2.0
> 0.02 mL – 0.05 mL	10	10	15
	50	2.0	3.0
	100	1.0	1.5
> 0.05 mL – 0.2 mL	10	10	10
	50	2.0	2.0
	100	1.0	1.0
> 0.2 mL – 0.5 mL	10	10	6.0
	50	2.0	1.2
	100	1.0	0.60

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 maximum permissible errors	
		systematic	random
		± %	%
> 0.5 mL – 1 mL	10	10	4.0
	50	2.0	0.80
	100	1.0	0.40
> 1 mL – 2 mL	10	8.0	4.0
	50	1.6	0.80
	100	0.80	0.40
> 2 mL – 5 mL	10	6.0	3.0
	50	1.2	0.60
	100	0.60	0.30
> 5 mL – 25 mL	10	5.0	3.0
	50	1.0	0.60
	100	0.50	0.30
> 25 mL – 200 mL	10	5.0	2.5
	50	1.0	0.50
	100	0.50	0.25

8.14.4 Single stroke dispenser

- Varispenser
- Varispenser plus
- Varispenser 2
- Varispenser 2x

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 maximum permissible errors	
		systematic	random
		± %	%
0.01 mL	10	20	10
	50	4.0	2.0
	100	2.0	1.0
> 0.01 mL – 0.02 mL	10	20	5.0
	50	4.0	1.0
	100	2.0	0.50
> 0.02 mL – 0.05 mL	10	15	4.0
	50	3.0	0.80
	100	1.5	0.40
> 0.05 mL – 0.1 mL	10	15	3.0
	50	3.0	0.60
	100	1.5	0.30
> 0.1 mL – 0.2 mL	10	10	3.0
	50	2.0	0.60
	100	1.0	0.30
> 0.2 mL – 0.5 mL	10	10	2.0
	50	2.0	0.40
	100	1.0	0.20
> 0.5 mL – 200 mL	10	6.0	2.0
	50	1.2	0.40
	100	0.60	0.20

8.14.5 Mechanical piston-stroke burettes

- Top Burette H
- Top Burette M

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 maximum permissible errors	
		systematic	random
		± %	%
5 mL	10	25	20
	50	6.0	4.0
	100	3.0	2.0
> 5 mL – 20 mL	10	20	8.0
	50	4.0	1.6
	100	2.0	0.80
> 20 mL – 50 mL	10	18	4.0
	50	3.6	0.80
	100	1.8	0.40
> 50 mL – 100 mL	10	15	2.0
	50	3.0	0.40
	100	1.5	0.20
> 100 mL – 200 mL	10	10	2.0
	50	2.0	0.40
	100	1.0	0.20
> 200 mL – 500 mL	10	8	2.0
	50	1.6	0.40
	100	0.80	0.20
> 500 mL – 1000 mL	10	6.0	1.5
	50	1.2	0.30
	100	0.60	0.15

9 Adjustment

Making an adjustment sets the dispensing volume in such a way that systematic error is minimized for the intended application.

An adjustment can be useful due to deviating calibration results or due to deviating conditions.



An adjustment does not influence the random error. The random error can be reduced by exchanging worn parts. The random error is also influenced by

- ▶ Adjust the dispenser (see product information www.eppendorf.com/manuals).



The dispenser can also be sent to the authori

9.1 Adjustment for different calibration results

If calibration results for mechanical pipettes are outside of permissible thresholds, adjustment may be required.



In contrast to mechanical pipettes, an electronic pipette is adjusted over the complete stroke length with a fifth-degree polynomial function. The factory settings for electronic pipettes can therefore not be adjusted by the user. If the measurement results are outside of manufacturer thresholds, the pipette is defective and must be sent to an authorized service provider.

9.2 Adjusting in case of deviating conditions

The physical properties of liquids and the ambient conditions are significant influencing factors for piston stroke. Therefore no pipette can be adjusted by the user. If the pipette is defective and must be sent to an authorized service provider.

9.1.1 Checking the reason for dispensing deviations

All external influences must be excluded before adjusting a pipette.

- Tip cone is OK
- The pipette tip is compatible with pipette
- The dispensing system is sealed (pipette and pipette tip)
- The test liquid was absorbed and dispensed 5 times (saturated air cushion)
- The test liquid, dispenser and ambient air have the same temperature
- Test liquid is in accordance with the requirements of ISO 3696
- The immersion depth during liquid aspiration is observed

Changing the adjustment is useful in the following cases:

- Liquids whose physical properties (density, viscosity, surface tension, vapor pressure) differ significantly from those of water
 - Capillary action during the immersion of the pipette tip (e.g., in the case of DMSO)
 - Changes in the atmospheric pressure due to the altitude at which the pipette is used
 - Pipette tips whose geometry differs significantly from standard tips (e.g., epT.I.P.S.)
- ▶ Adjust dispenser (see product information www.eppendorf.com/manuals).

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