eppendorf

Standard Operating Procedure

Standard operating procedure for manual dispensing tools

ASOP P39 020-11/052019

Table of contents

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.

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

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

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 AG 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.

ISO 8655
The standard defines limit values for the systematic error, the random error and the test methods for dispensers.

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 ISO 8655 and in accordance with manufacturer limits of Eppendorf AG.

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 maximum dispensing volume of a dispensing system specified by the manufacturer.

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.

T

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

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.

Viscosity
Viscosity describes the viscidity 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

This version describes the procedure for calibrating multi-channel lower parts with 16 and 24 channels.The 16 and 24 channel lower parts have a cone spacing of 4.5 mm.The analytical balances available on the market have the smallest load cell spacing of 9 mm.Since there is currently no international standard for the calibration of multichannel bases with a cone spacing of 4.5 mm, ISO 8655 is not fully applicable.

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 ISO 8655-6 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
11	2019-05	• 16-channel and 24-channel pipettes added to preface • Calibration instruction of 16-channel and 24-channel pipettes added • Calibration instructions for multiple-channel pipettes specified more precisely • Correction of the measured value deviations for Multipette M4 and Multipette E3/E3x • New 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
10	2016-04	• 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	• Document number updated
08	2013-05	• Pipette Reference 2 added
07	2013-04	• Design change

1.4 Supported dispensers

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

1.4.1 Mechanical piston stroke pipettes – air-cushion principle

- Reference
- Reference 2
- Research
- Research plus

1.4.2 Electronic piston stroke pipettes – air-cushion principle

- Research pro
- 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

1.4.8 Mechanical bottle-top burette – positive displacement principle

- Top Burette M
- Top Burette H

2 Cleaning and service information

Regular cleaning and service of the dispensers ensures that the specified errors of measurement are complied with. How often a dispenser has to be cleaned and serviced depends on the utilization intensity and the dispensed chemicals. In the case of intensive use or if aggressive chemicals are dispensed, shorter cleaning intervals are feasible.

Eppendorf recommends keeping a service log for the dispensers or recording service details in the calibration protocol.

Information on cleaning, upkeep, maintenance, sterilization and disinfection can be found in the operating manual of the respective dispensers. The specifications in the "Maintenance" chapter of the operating manual of the respective dispenser must be complied with.

The operating manuals are available from the website www.eppendorf.com/manuals.

Cleaning/service must be performed prior to a calibration.

Exception: If the current state of the dispenser is to be recorded to draw conclusions about analysis results, a calibration prior to service may be feasible. In this case, a second calibration is performed after cleaning/service.

2.1 Cleaning and maintaining piston stroke pipettes - air-cushion principle

2.1.1 Single-channel pipettes

1. Clean the exterior of the housing.
2. Remove, clean and dry the lower part.
3. If necessary, autoclave the pipette.
4. Check piston seal for damage.
5. Replace damaged piston seal.
6. If necessary, lubricate the piston or cylinder.
7. Assemble the lower part.
8. Check the leak tightness.

2.1.2 Multi-channel pipettes

1. Clean the exterior of the housing.
2. Remove, clean and dry the lower part.
3. If necessary, autoclave the pipette.
4. Open the multi-channel lower part.
5. Check piston seal for damage.
6. Replace damaged piston seals.
7. If necessary, lubricate cylinder.
8. Assemble the lower part.
9. Replace the O-rings of the tip cones (100 µL – 1200 µL).
10. Check the leak tightness.

Only use the "grease for pipettes" by Eppendorf AG.The grease is autoclavable and ensures optimum slide properties of the piston.As long as the grease is not contaminated, it does not have to be replaced.The grease can be ordered as an accessory.

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

1. Please note the information in the document "Decontamination certificate for product returns".
   It is available as PDF document on our website www.eppendorf.com/decontamination.
2. Enter the serial number of the device in the decontamination certificate.
3. Enclose the completed decontamination certificate for returned goods with the device.
4. Send the device to Eppendorf AG or an authorized service center.

3 Error causes and solutions

Problem	Cause	Solution
Pipette is dripping	• Pipette tip is loose.	▶ Attach pipette tip again.
	• Incorrect pipette tip used.	▶ Use original Eppendorf pipette tip.
	• Piston is damaged.	▶ Exchange piston and piston seal.
	• Seal is damaged.	▶ Replace seal.
	• Liquid with slightly increased vapor pressure used.	▶ Pre-wet pipette tip several times.
	• Liquid with high vapor pressure used.	▶ Use positive-displacement device.
Wrong dispensing volume of multi-dispensers	• Dispensing tip is not leak-tight.	▶ Use new dispensing tip.
	• Dispensing tip is too warm.	▶ Ensure even temperature.
Control button is stiff	• Piston is contaminated.	▶ Clean and grease piston.
	• Seal is contaminated.	▶ Clean seal.
	• Seal is damaged.	▶ Exchange seal.
	• Piston is damaged.	▶ Replace piston.
	• Solvent vapors entered the pipette.	▶ Remove and disassemble lower part. ▶ Clean and grease piston.

4 Test intervals

The change of the systematic and random error is a gradual process. It is especially accelerated by aggressive chemicals. There is no general rule or basis of calculation for determining sensible time intervals.

Calibration results documented over a longer period can be used to draw conclusions as to an individual calibration frequency.

Test intervals can be specified by laboratory regulations. ISO 8655 requires annual calibration.

Shorter time intervals regarding maintenance, service and calibration depend on the factors:

- Frequency of use
- Accuracy required from the dispenser
- Handling
- Chemicals
- Laboratory regulations

5 Types of tests

There are different methods for testing a dispensing system. The easiest and most frequently performed check is a visual inspection for damage to and contamination of the dispenser. The individual test methods are described in the following chapters.

A calibration can be performed with the following processes:

- Titrimetric
- Photometric
- Gravimetric (reference process ISO 8655)

5.1 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.

5.2 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.

5.3 Checking leak tightness of dispensers with air cushion principle

Prerequisites

- Ambient temperature is constant
- Ambient temperature is between 20 °C – 25 °C
- Relative humidity > 50 %
- epT.I.P.S. test tip
- Test liquid: demineralized water
- Dispenser, test tip and test liquid are at ambient temperature

1. Set pipette to nominal volume.
2. Attach the pipette tip.
3. Fill and empty the pipette tip 5 times.
   This saturates the vapor phase in the air cushion and no more test liquid evaporates.
4. Aspirate nominal volume.
5. Hang the pipette into a holder in vertical position.

ℹ The pipette can be held vertically with two fingers. The hand temperature must not be transferred to the pipette.

5.3.1 Dispensing system is leak-tight

The dispensing system is leak-tight if **no** liquid drop forms at the pipette tip within 15 seconds.

5.3.2 Dispensing system is not leak-tight

The dispensing system is not leak-tight if a liquid drop forms at the pipette tip within 15 seconds.

1. Check the assembly of the pipette.
2. Check the piston seal for damage.
   Exchange defective piston seal.
3. Repeat tightness test.

5.4 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.

5.5 Intermediate check – Quick-Check

The Quick-Check is a shortened calibration with 4 measurements per volume.With 4 measured values the statistical safety is **not** ensured.The Quick-Check is therefore no substitute for a complete calibration with 10 measured values per volume.

If the measurement results are outside the specified tolerances, the dispenser must be calibrated.

5.6 Conformity test

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

The conformity test tests if a dispensing system is within the specified measuring tolerances. For this purpose, a calibration with 10 measured values per volume is performed. The user can freely determine the thresholds within the ISO thresholds. In calibration laboratories tests are typically performed according to the manufacturer thresholds and conformity with these thresholds is assessed.

6 Prerequisites for gravimetric testing

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

6.1 Measuring place setup

A fully equipped measuring place 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
- Hygrometer
- Barometer
- Storage container for test liquid
- Test liquid (demineralized water)
- Test tips

6.1.1 Analytical balance and 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 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

Nominal volume dispenser	Resolution of the balance
1 µL – 10 µL	0.001 mg
10 µL – 100 µL	0.01 mg
100 µL – 1000 µL	0.1 mg
1 mL – 10 mL	0.1 mg
10 mL – 200 mL	1 mg

The weighing vessel should meet the following requirements:

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

6.1.2 Measuring place

The measuring place should meet the following requirements:
- Draft-free
- Vibration-free workplace
- Relative humidity > 50 %
- Ambient temperature 15 °C – 30 °C, ±0,5 °C
- No direct heat radiation

6.2 Test liquid

Distilled or demineralized water is used as test liquid. The reservoir for the test liquid should be sealable with a lid. This protects the test liquid from a drop in temperature due to evaporative cooling and dust particles do not contaminate the test liquid.

The test liquid must meet the following requirements (ISO 3696):
- Conductivity: ≤ 0.5 mS/m at 25 °C
- Water temperature corresponds to ambient temperature
- Degassed or at equilibrium with air

6.3 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

6.4 Data transfer and data evaluation

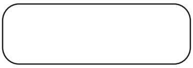
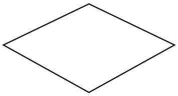
A calibration software is a useful means to automatically record the measured values obtained with gravimetric methods, convert measured values into corrected volumes and calculate the errors of measurement from these values.

6.5 Other test conditions

The duration of the test cycle (time required for weighing a dispensed volume) must be as short as possible. ISO 8655 specifies a maximum time of 60 seconds. For all listed dispensers, the inspection is performed by determining the dispensing volume in the weighing vessel (ex).

7 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.

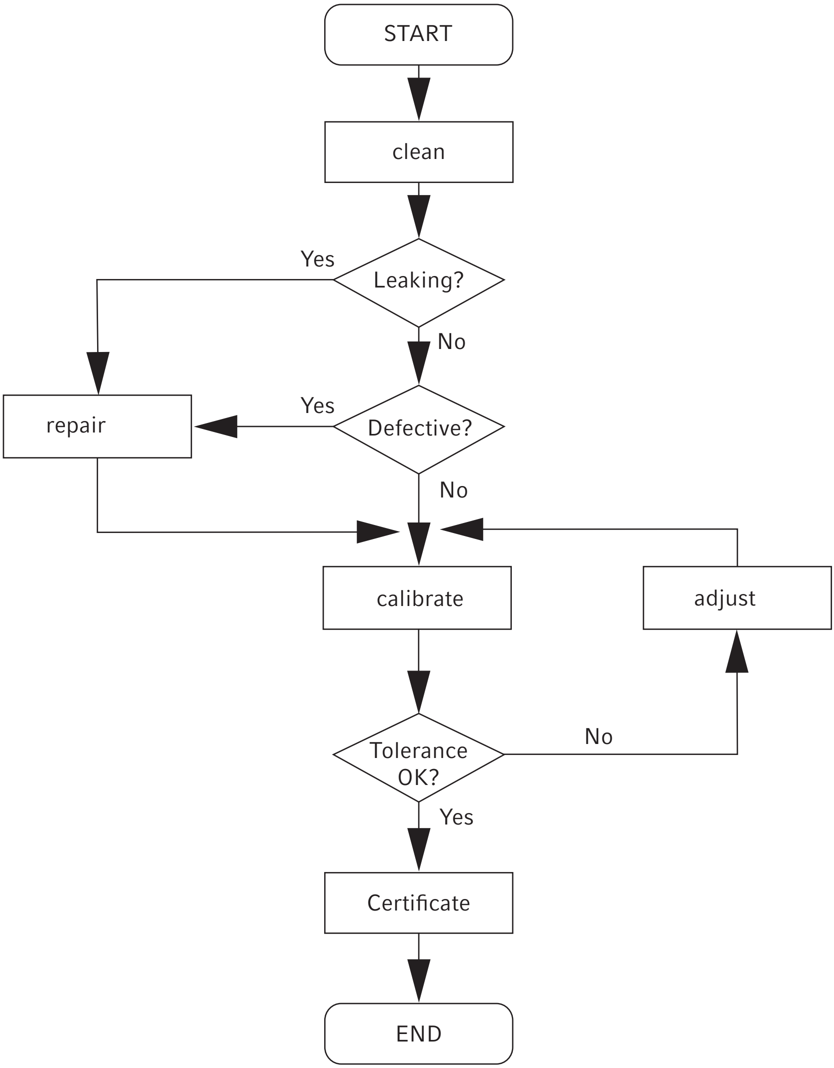


Fig. 7-1: Complete calibration procedure

7.1 Preparing the measuring place for calibration

7.1.1 Preparing the dispenser, test liquid and analytical balance

Prerequisites

- Dispenser has been cleaned.
- Defective parts of the dosing unit have been replaced.
- Dispenser has been decontaminated if necessary.

▶ 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.

7.1.2 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.

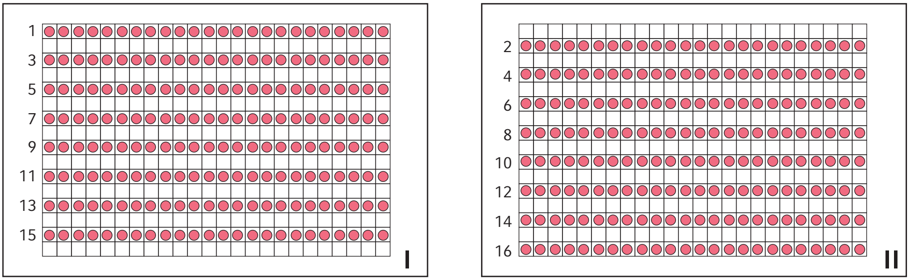


Fig. 7-2: Reusable boxes for test runs **I** and **II**

7.1.3 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.

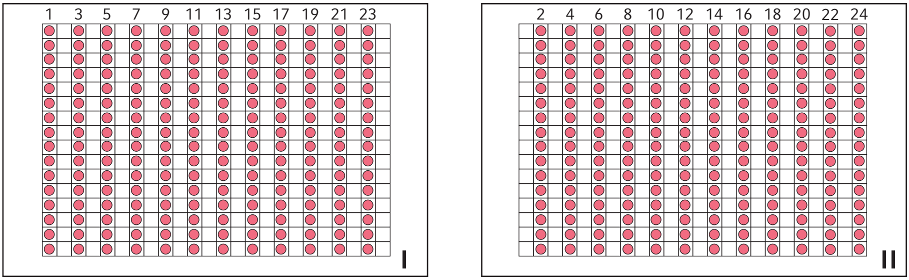


Fig. 7-3: Reusable boxes for test runs **I** and **II**

7.1.4 Preparing the documentation

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

7.2 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

7.2.1 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 is between 15 °C – 30 °C		
A05	Relative humidity is > 50 %		
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)		

7.2.2 B – Test liquid

Number	Description	Yes	No	Not available
B01	Test liquid is available (according to ISO 3696).			
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 is filled at least 2 hours before calibration.			
B07	Bottle-top dispenser:Test liquid is filled at least 2 hours before calibration.			

7.2.3 C – Dispenser

Number	Description	Yes	No	Not available
C 01	Dispenser has been cleaned.			
C 02	Defective parts have been replaced.			

Number	Description	Yes	No	Not available
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.			

7.2.4 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.		

7.2.5 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.			

7.3 Conducting a series of measurements

The measured values of a series of measurements should be determined at the same time.This reduces the risk of errors or deviations between the measured values.

7.3.1 Nominal volume

The nominal volume of a piston-stroke pipette is imprinted and is the largest adjustable volume.

For mechanical dispensers, the nominal volume depends on:

- the selector dial position
- the volume of the dispenser tip

For electronic dispensers, the nominal volume depends on the volume of the dispenser tip and the largest adjustable volume.

7.3.2 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

Channels	Measured values
4	120
6	160
8	240
12	360
16	480
24	720

7.3.3 Number of equipped tip cones - 8-channel and 12-channel lower parts

All channels must be equipped with a pipette tip and filled with test liquid, even if only one channel can be measured gravimetrically.

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

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).

7.3.5 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)

7.3.6 Overview of the calibration procedures

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

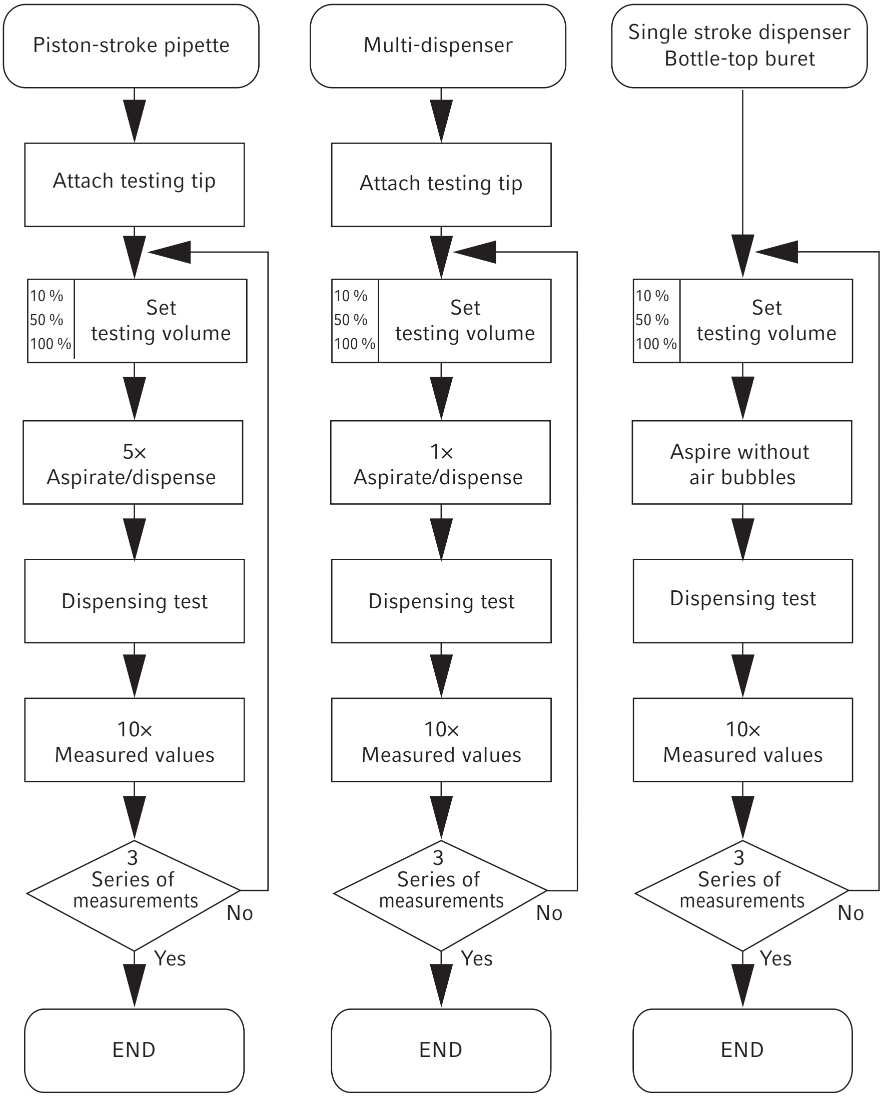


Fig. 7-4: Calibration procedure of the device groups

7.3.7 Determining measured values - mechanical single-channel pipettes

Prerequisites

- Test tip has been attached.

The test tip can be used for the entire calibration.

1. Adjust the test volume.
2. Absorb and dispense the test liquid 5 times.
3. Immerse test tip a few millimeters vertically in the test liquid.
4. Maintain immersion depth and absorb the test liquid slowly and evenly.
5. Wait until the liquid absorption is finished (several seconds).
6. Remove the test tip from the liquid.
7. Place the test tip on the tube inner wall at a steep angle.
8. Perform test dispensing procedure.
9. Determine measured values for each test volume.

7.3.8 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.

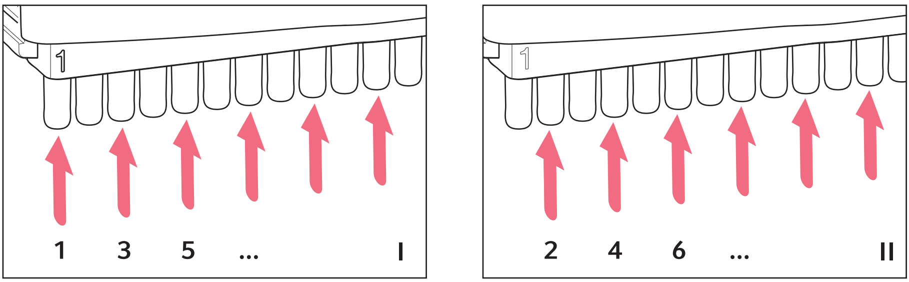


Fig. 7-5: Equipping the tip cones for test runs **I** and **II**

7.3.9 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 test tips a few millimeters vertically in the test liquid.
5. Maintain immersion depth and absorb the test liquid slowly and evenly.
6. Wait until the liquid absorption is finished (several seconds).
7. Remove the test tips from the liquid.
8. Place the test tips on the tube inner wall at a steep angle.
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 test tips a few millimeters vertically in the test liquid.
15. Maintain immersion depth and absorb the test liquid slowly and evenly.
16. Wait until the liquid absorption is finished (several seconds).
17. Remove the test tips from the liquid.
18. Place the test tips on the tube inner wall at a steep angle.
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**.

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

Prerequisites

- Test tips have been attached to all channels.

> The test tips can be used for the entire calibration.

Each channel must be tested individually.For this purpose, either an analytical balance with one load cell per channel or a device with a drain channel is used to discard the liquid from the other channels.

1. Adjust the test volume.
2. Absorb and dispense the test liquid 5 times.
3. Immerse test tips a few millimeters vertically in the test liquid.
4. Maintain immersion depth and absorb the test liquid slowly and evenly.
5. Wait until the liquid absorption is finished (several seconds).
6. Remove the test tips from the liquid.
7. Place the test tip of the channel to be tested on the tube inner wall at a steep angle.
8. Perform test dispensing procedure.
9. Determine measured values for each channel and for each test volume.

7.3.11 Determining measured values - electronic single-channel pipettes

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.

> The test tips can be used for the entire calibration.

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 test tip a few millimeters vertically in the test liquid.
7. Maintain immersion depth and absorb test liquid.
8. Wait until the liquid absorption is finished (several seconds).
9. Remove the test tip from the liquid.
10. Place the test tip on the tube inner wall at a steep angle.
11. Transfer the test liquid to the tube inner wall.
12. Determine measured values for each test volume.

7.3.12 Determining measured values - electronic multi-channel pipettes with 4.5 mm

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.

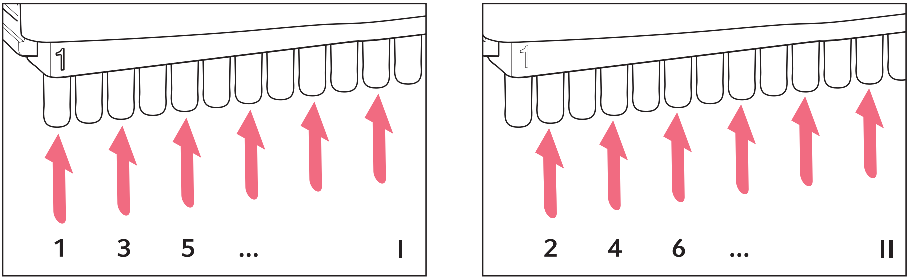


Fig. 7-6: Equipping the tip cones for test runs **I** and **II**

7.3.13 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. 49)*.
3. Set the operating mode (see *Test conditions on p. 49)*.
4. Adjust the test volume.
5. Absorb and dispense the test liquid 5 times.
6. Immerse test tips a few millimeters vertically in the test liquid.
7. Maintain immersion depth and absorb test liquid.
8. Wait until the liquid absorption is finished (several seconds).
9. Slowly remove the test tips from the liquid.
10. Place the test tips on the tube inner wall at a steep angle.
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 test tips a few millimeters vertically in the test liquid.
17. Maintain immersion depth and absorb test liquid.
18. Wait until the liquid absorption is finished (several seconds).
19. Slowly remove the test tips from the liquid.
20. Place the test tips on the tube inner wall at a steep angle.
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**.

7.3.14 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.

The test tips can be used for the entire calibration.

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 test tips a few millimeters vertically in the test liquid.
7. Maintain immersion depth and absorb test liquid.
8. Wait until the liquid absorption is finished (several seconds).
9. Slowly remove the test tips from the liquid.
10. Place the test tip of the channel to be tested on the tube inner wall at a steep angle.
11. Perform test dispensing procedure.
12. Determine measured values for each test volume.

7.3.15 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 calibration according to the test tip used.
4. Perform test dispensing procedure.
5. Determine measured values for each test volume.

7.3.16 Determining measured values - mechanical multiple-dispensers

Eppendorf recommends the use of the 5-mLCombitips 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. Adjust the test volume.
3. Immerse test tips a few millimeters vertically in the test liquid.
4. Maintain immersion depth and absorb test liquid.
5. Wait until the liquid absorption is finished (several seconds).
6. Slowly remove the test tips from the liquid.
7. Place the test tip on the tube inner wall at a steep angle.
8. Perform test dispensing procedure.
9. Determine measured values for each test volume.

7.3.17 Determining measured values - electronic multiple-dispensers

Eppendorf recommends the use of the 5-mLCombitips 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. Adjust the test volume.
4. Immerse test tips a few millimeters vertically in the test liquid.
5. Maintain immersion depth and absorb test liquid.
6. Wait until the liquid absorption is finished (several seconds).
7. Slowly remove the test tips from the liquid.
8. Place the test tip of the channel to be tested on the tube inner wall at a steep angle.
9. Perform test dispensing procedure.
10. Determine measured values for each test volume.

7.3.18 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.

7.3.19 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.

8 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.

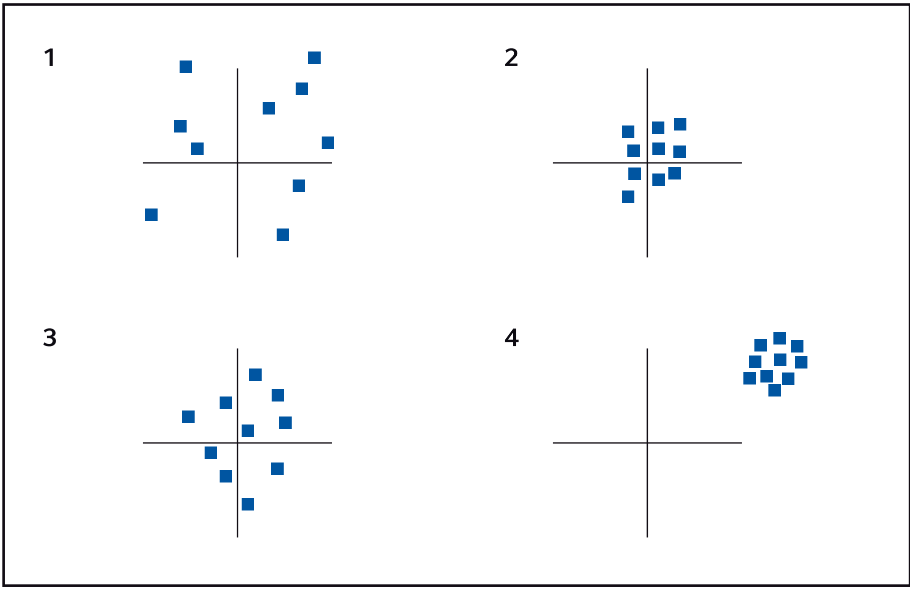


Fig. 8-1: Distribution of measured values

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

8.1 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	Measured gravimetric value
V_i	Volume value

8.2 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

8.3 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
n	Number of measurements

8.4 Calculating the systematic error of measurement

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

8.4.1 Absolute systematic error of measurement

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

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

8.4.2 Relative systematic error of measurement

$$e_s = \frac{(\overline{V} - V_s) \cdot 100\ \%}{V_s}$$

- 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	Systematic error of measurement
$\overline{V}$	Mean volume value
V_s	Testing volume

8.5 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.

8.5.1 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.

8.5.2 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

8.6 Test report

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

8.6.1 Tester

Name	
First name	
Department	
Calibration date	

8.6.2 Dispenser

Manufacturer	
Type	
Model number	
Nominal volume	
Serial number	

8.6.3 Test tip

Manufacturer	
Designation	
Volume	
Lot number	

8.6.4 Analytical balance

Manufacturer	
Model	
Serial number	
Last calibration	

8.6.5 Adjustment

Basis for adjustment (Ex)	
Adjustment carried out by	

8.6.6 Test conditions

Air temperature °C	
Air pressure hPa	
Relative humidity %	
Test liquid temperature °C	

8.6.7 Test method

ISO 8655	
Laboratory regulation	
Manufacturer's specifications	
Other	

8.6.8 Measurement series

Measurement series 1										
Measured values										

	Actual value	**Set value**	**Assessment**
Average value $\overline{V}$			
Systematic error of measurement e_s			
Random error of measurement CV			
Comment			

Measurement series 2										
Measured values										

	Actual value	**Set value**	**Assessment**
Average value $\overline{V}$			
Systematic error of measurement e_s			
Random error of measurement CV			
Comment			

Measurement series 3										
Measured values										

	Actual value	**Set value**	**Assessment**
Average value $\overline{V}$			
Systematic error of measurement e_s			
Random error of measurement CV			
Comment			

8.6.9 Cleaning

Name	
First name	
Department	
Date	
Comment	

8.6.10 Maintenance

Name	
First name	
Department	
Date	
Replaced parts	
Comment	

9 Permissible errors of measurement

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

9.1 Test conditions

Test conditions and test evaluation in compliance with ISO 8655, Part 6. Tested using a standardized analytical balance with evaporation protection.

The three largest testing volumes per tip (10 %, 50 %, 100 % of the nominal volume) correspond to the specifications in accordance with ISO 8655, Part 2 or Part 5. The test is to be carried out with these three testing volumes for testing of the systematic and random error in compliance with the standard. The smallest adjustable volume serves to provide additional information.

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

9.1.1 Multipette E3/E3x

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

9.1.2 Multipette stream/Xstream

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

9.1.3 Research pro

- Operating mode: **Pip**
- Speed level: Maximum

9.1.4 Xplorer/Xplorer plus

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

9.2 Biomaster – Error of measurement

Model	Test tip Mastertip	Testing volume	Error of measurement			
			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
		3 µL	5.0	0.15	3.0	0.09
		5 µL	4.0	0.2	2.0	0.1
		10 µL	3.0	0.3	1.5	0.15
		20 µL	2.0	0.4	0.8	0.16

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

Test tip Combitips advanced	Volume range	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.1 mL 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 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 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 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 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 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 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	Error of measurement			
			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

Test tip ViscoTip	Volume range	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
10 mL 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

9.4 Multipette M4 – Repeater M4 - error of measurement

Test tip Combitips advanced	Dispensing volume	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.1 mL 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 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 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 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 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 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 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	Error of measurement			
			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

Test tip ViscoTip	Dispensing volume	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
10 mL orange	0.1 mL – 2 mL	0.1 mL	n/a	n/a	n/a	n/a
		0.2 mL	8	16	4	8
		1 mL	1.6	16	0.8	8
		2 mL	0.8	16	0.5	8

9.5 Multipette plus – Repeater plus - error of measurement

Test tip Combitips advanced	Volume range	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.1 mL 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 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 violet	5 µL – 50 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 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 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 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 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 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 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

9.6 Multipette/Repeater stream/Xstream - error of measurement

Test tip Combitips advanced	Volume range	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.1 mL 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 light blue	2 µL – 200 µL	20 µL	1.3	0.26	1.5	0.3
		100 µL	1.0	1.0	1.0	1.0
		200 µL	1.0	2.0	0.5	1.0
0.5 mL 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 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 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 blue	50 µLd – 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 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 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 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

9.7 Reference - error of measurement

9.7.1 Reference - Single-channel pipette with fixed volume

Model	Test tip epT.I.P.S.	Error of measurement			
		systematic		random	
		± %	± µL	± %	± µL
1 µL light gray	0.5 µL – 20 µLL light gray 46 mm	2.5	0.025	1.8	0.018
2 µL light gray		2.0	0.04	1.2	0.024
5 µL light gray		1.5	0.075	0.8	0.04
10 µL light gray		1.0	0.1	0.5	0.05
10 µL yellow	2 µL – 200 µL yellow 53 mm	1.0	0.1	0.5	0.05
20 µL yellow		0.8	0.16	0.3	0.06
25 µL yellow		0.8	0.2	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 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
1500 µL red	500 µL – 2500 µL red 115 mm	0.6	9.0	0.2	3.0
2000 µL red		0.6	12	0.2	4.0
2500 µL red		0.6	15	0.2	5.0

9.7.2 Reference - Single-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.1 µL – 2.5 µL dark gray	0.1 µL – 10 µL dark gray 34 mm	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 light gray	0.5 µL – 20 µL light gray 46 mm	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 light gray	0.5µL – 20 µL light gray 46mm	2 µL	3.0	0.06	2.0	0.04
		10 µL	1.0	0.1	0.5	0.05
		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	0.1	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 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	0.15	0.15
50 µL – 200 µL yellow	2 µL – 200 µL yellow 53 mm	50 µL	1.0	0.5	0.3	0.15
		100 µL	0.9	0.9	0.3	0.3
		200 µL	0.6	1.2	0.2	0.4
50 µL – 250 µL blue	50 µL – 1000 µL blue 71 mm	50 µL	1.4	0.7	0.3	0.15
		100 µL	1.1	1.1	0.3	0.3
		250 µL	0.6	1.5	0.2	0.5
100 µL – 1000 µL blue	50 µL – 1000 µL blue 71 mm	100 µL	3.0	3.0	0.3	0.3
		500 µL	1.0	5.0	0.2	1.0
		1000 µL	0.6	6.0	0.2	2.0
500 µL – 2500 µL red	500 µL – 2500 µL red 115 mm	0.5 mL	1.5	7.5	0.3	1.5
		1.25 mL	0.8	10	0.2	2.5
		2.5 mL	0.6	15	0.2	5.0

9.8 Reference 2 - error of measurement

9.8.1 Reference 2 - Single-channel pipette with fixed volume

Model	Test tip epT.I.P.S.	Error of measurement			
		systematic		random	
		± %	± µL	± %	± µL
1 µL dark blue	0.1 µL – 10 µL dark blue 34 mm	2.5	0.025	1.8	0.018
2 µL dark blue		2.0	0.04	1.2	0.024
5 µL blue	0.1 µL – 20 µL blue 40 mm	1.2	0.06	0.6	0.03
10 µL blue		1.0	0.1	0.5	0.05
20 µL light blue	0.5 µL – 20 µLL light blue 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
2.0 mL red	0.5 mL – 2.5 mL red 115 mm	0.6	12	0.2	4
2.5 mL red		0.6	15	0.2	5

9.8.2 Reference 2 - Single-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			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 µLL 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
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

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			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
		5.0 mL	0.6	30	0.15	7.5
1 mL – 10 mL turquoise	1 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

9.8.3 Reference 2 - Multi-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			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

9.9 Research - error of measurement

9.9.1 Research - Single-channel pipette with fixed volume

Model	Test tip epT.I.P.S.	Error of measurement			
		systematic		random	
		± %	± µL	± %	± µL
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 blue	0.05 mL – 1 mL 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

9.9.2 Research - Single-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.1 µL – 2.5 µL dark gray	0.1 µL – 10 µL dark gray 34 mm	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 light gray	0.5 µL – 20 µLL light gray 46 mm	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 yellow	2 µL – 200 µL0 yellow 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 yellow	2 µL – 200 µL yellow 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	0.20
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
100 µL – 1000 µL blue	0.05 mL – 1 mL 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
0.5 mL – 5 mL violet	0.1 mL – 5 mL violet 120 mm	0.5 mL	2.4	12	0.6	3.0
		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	1 mL – 10 mL turquoise 165 mm	1.0 mL	3.0	30	0.6	6.0
		5.0 mL	0.8	40	0.2	10
		10.0 mL	0.6	60	0.15	15

9.9.3 Research - Multi-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.5 µL – 10 µL light gray	0.5 µL – 20 µLL light gray 46 mm	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

9.10 Research plus - error of measurement

9.10.1 Research plus - Single-channel pipette with fixed volume

Model	Test tip epT.I.P.S.	Error of measurement			
		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 – 20µLL 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	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

9.10.2 Research plus - Single-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.1 µL – 2.5 µL dark gray	0. µL – 10 µL dark gray 34 mm	0. 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.	0.019
		2.5 µL	1.4	0.035	0.7	0.018
0. µL – 10 µL medium gray	0.1 µL – 20µL medium gray 40 mm	0. 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 light gray	0.5 µL – 20µLL light gray 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 yellow	2 µL – 200 µL yellow 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 yellow	2 µL – 200 µL yellow 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 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
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	0.25mL	4.8	12	1.2	3
		1.25mL	0.8	10	0.2	2.5
		2.5mL	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

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
1 mL – 10 mL turquoise	1 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

9.10.3 Research plus - Multi-channel pipettes with fixed cone spacing

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.5 µL – 10 µL medium gray 8/12-channel	0.1 µL – 20 µL medium gray 40 mm	0.5µL	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 pearl white 16/24-channel	1 µL – 20 µL pearl white 42 mm	1µL	12	0.12	8	0.08
		2µL	8	0.16	5	0.1
		10µL	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
120 µL – 1200 µL dark green 8/12-channel	50 µL – 1250 µL 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

9.11 Research pro - error of measurement

9.11.1 Research pro - Single-channel pipette with variable volume

Model	**Test tip epT.I.P.S.**	**Testing volume**	**Error of measurement**			
			systematic		**random**	
			± %	**± µL**	**± %**	**± µL**
0.5 µL – 10 µL light gray	0.5 µL – 20 µLL light gray 46 mm	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
5 µL – 100 µL yellow	2 µL – 200 µL yellow 53 mm	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
20 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
50 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
100 µL – 5000 µL violet	0.1 mL – 5 mL violet 120 mm	0.5 mL	3.0	15	0.6	3.0
		2.5 mL	1.2	30	0.25	6.25
		5.0 mL	0.6	30	0.15	7.5

9.11.2 Research pro - Multi-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.5 µL – 10 µL	0.5 µL – 20 µLL light gray 46 mm	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
5 µL – 100 µL	2 µL – 200 µL yellow 53 mm	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
20 µL – 300 µL	20 µL – 300 µL orange 55 mm	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 – 1250 µL	50 µL – 1250 µL green 76 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

9.12 Top Buret M/H - error of measurement

9.12.1 Top Buret M

Model M	Testing volume	Error			
		Systematic error		Random error	
		± %	± 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

9.12.2 Top Buret H

Model H	Testing volume	Error			
		Systematic error		Random error	
		± %	± 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

9.13 Varipette - error of measurement

Model	Test tip	Testing volume	Error of measurement			
			systematic		random	
			± %	± mL	± %	± mL
2.5 mL – 10 mL	Varitip 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	Varitip P	1 mL	0.6	0.006	0.2	0.002
		5 mL	0.5	0.025	0.1	0.005
		10 mL	0.3	0.03	0.1	0.01

9.13.1 Maxipettor - error of measurement

Model	Test tip	Testing volume	Error of measurement			
			systematic		random	
			± %	± mL	± %	± mL
2.5 mL – 10 mL	Maxitip 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	Maxitip P	1 mL	0.6	0.006	0.2	0.002
		5 mL	0.5	0.025	0.1	0.005
		10 mL	0.3	0.03	0.1	0.01

9.14 Varispenser/Varispenser plus - error of measurement
9.14.1 Varispenser

Model	Testing volume	Error of measurement			
		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

9.14.2 Varispenser plus

Model	Testing volume	Error of measurement			
		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

9.15 Xplorer/Xplorer plus - error of measurement

9.15.1 Xplorer/Xplorer plus - Single-channel pipette with variable volume

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.5 µL – 10 µL medium gray	0.1 µL – 20 µL medium gray 40 mm	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	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	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	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	15 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
50 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
		1000 µL	0.6	6.0	0.2	2
0.1 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
0.2 mL – 5 mL violet	0.1 mL – 5 mL violet 120 mm	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	1 mL – 10 mL turquoise 165 mm	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

9.15.2 Xplorer/Xplorer plus - Multi-channel pipettes with fixed cone spacing

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			systematic		random	
			± %	± µL	± %	± µL
0.5 µL – 10 µL medium gray 8/12-channel	0.1 µL – 20 µL medium gray 40 mm	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 pearl white 16/24-channel	1 µL – 20 µL white 42 mm	1µL	12	0.12	8	0.08
		2µL	8	0.16	5	0.1
		10µL	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	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
15 µL – 300 µL orange 8/12-channel	15 µL – 300 µL orange 55 mm	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	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

9.16 Maximum permissible errors according to EN ISO 8655

The maximum permissible errors always refer to the entire pipette and pipette tip system.If the nominal volume of the pipette is between two values, the absolute permissible errors apply to the next larger nominal volume.The absolute permissible errors related to the nominal volume apply to each adjustable volume.The following is an example for calculating the relative permissible errors of nominal volumes not listed in the ISO tables.Furthermore, the absolute and relative permissible errors are listed as a function of the volume.For multi-channel pipettes, the maximum permissible errors are twice the values specified for single-channel pipettes.

9.16.1 Example - Reference 2

The absolute errors of measurement of the nominal volume are applied to all other adjustable volumes.For this purpose, calculate the proportional error of measurement from the absolute measurement error at nominal volume as follows for the respective adjustable volume.

100% nominal volume:
- Nominal volume: 2500 µL
- Absolute systematic error of measurement:40 µL
- Relative systematic error of measurement:1.6%
- Absolute random error of measurement:15 µL
- Relative random error of measurement:0.6%

50% nominal volume:
- Useful volume: 1250 µL
- Absolute systematic error of measurement:40 µL
- Relative systematic error of measurement:3,2 %
- Absolute random error of measurement:15 µL
- Relative random error of measurement:1.2%

10% nominal volume:
- Useful volume:250 µL
- Absolute systematic error of measurement:40 µL
- Relative systematic error of measurement:16%
- Absolute random error of measurement:15 µL
- Relative random error of measurement:6%

9.16.2 Air-cushion pipettes with fixed and variable volume

- Reference
- Reference 2
- Research
- Research plus
- Research pro
- Xplorer
- Xplorer plus

Nominal volume	Maximum permissible errors (ISO 8655)			
	systematic		random	
	± %	± µL	± %	± µL
1 µL	5.0	0.05	5.0	0.05
2 µL	4.0	0.08	2.0	0.04
5 µL	2.5	0.125	1.5	0.075
10 µL	1.2	0.12	0.8	0.08
20 µL	1.0	0.2	0.5	0.1
50 µL	1.0	0.5	0.4	0.2
100 µL	0.8	0.8	0.3	0.3
200 µL	0.8	1.6	0.3	0.6
500 µL	0.8	4.0	0.3	1.5
1000 µL	0.8	8.0	0.3	3.0
2000 µL	0.8	16	0.3	6.0
5000 µL	0.8	40	0.3	15.0
10000 µL	0.6	60	0.3	30.0

9.16.3 Positive displacement pipettes

- Biomaster
- Varipette/Maxipettor

Nominal volume	**Maximum permissible errors (ISO 8655)**			
	systematic		**random**	
	± %	**± µL**	**± %**	**± µL**
5 µL	2.5	0.13	1.5	0.08
10 µL	2.0	0.2	1.0	0.1
20 µL	2.0	0.4	0.8	0.16
50 µL	1.4	0.7	0.6	0.3
100 µL	1.5	1.5	0.6	0.6
200 µL	1.5	3.0	0.4	0.8
500 µL	1.2	6.0	0.4	2.0
1000 µL	1.2	12.0	0.4	4.0

9.16.4 Multi-dispenser

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

Nominal volume	**Maximum permissible errors (ISO 8655)**			
	systematic		**random**	
	± %	**± µL**	**± %**	**± µL**
0.001 mL	5.0	0.05	5.0	0.05
0.002 mL	5.0	0.1	5.0	0.1
0.003 mL	2.5	0.075	3.5	0.11
0.01 mL	2.0	0.2	2.5	0.25
0.02 mL	1.5	0.3	2.0	0.4
0.05 mL	1.0	0.5	1.5	0.75
0.1 mL	1.0	1.0	1.0	1.0
0.2 mL	1.0	2.0	1.0	2.0
0.5 mL	1.0	5.0	0.6	3.0
1 mL	1.0	10	0.4	4.0
2 mL	0.8	16	0.4	8.0
5 mL	0.6	30	0.3	15
10 mL	0.5	50	0.3	30
25 mL	0.5	125	0.3	75
50 mL	0.5	250	0.25	125
100 mL	0.5	500	0.25	250
200 mL	0.5	1000	0.25	500

9.16.5 Single stroke dispenser

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

Nominal volume	Maximum permissible errors (ISO 8655)			
	systematic		random	
	± %	± µL	± %	± µL
0.01 mL	2.0	0.2	1.0	0.1
0.02 mL	2.0	0.4	0.5	0.1
0.05 mL	1.5	0.75	0.4	0.2
0.1 mL	1.5	1.5	0.3	0.3
0.2 mL	1.0	2.0	0.3	0.6
0.5 mL	1.0	5.0	0.2	1.0
1 mL	0.6	6.0	0.2	2.0
2 mL	0.6	12.0	0.2	4.0
5 mL	0.6	30.0	0.2	10.0
10 mL	0.6	60.0	0.2	20.0
25 mL	0.6	150.0	0.2	50.0
50 mL	0.6	300.0	0.2	100
100 mL	0.6	600.0	0.2	200
200 mL	0.6	1200	0.2	400

9.16.6 Piston burets

- Top Burette H
- Top Burette M

Nominal volume	Maximum permissible errors (ISO 8655)			
	systematic		random	
	± %	± µL	± %	± µL
≤ 1 mL	0.6	6.0	0.1	1.0
2 mL	0.5	10	0.1	2.0
5 mL	0.3	15	0.1	5.0
10 mL	0.3	30	0.1	10
20 mL	0.2	40	0.1	20
25 mL	0.2	50	0.1	25
50 mL	0.2	100	0.1	50
100 mL	0.2	200	0.1	100

10 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 handling.

10.1 Adjusting in case of deviating calibration results

If the calibration results of mechanical pipettes are outside of the permissible thresholds, an adjustment may be necessary.

Compared to mechanical pipettes, an electronic pipette is adjusted with a fifth degree polynomial function along the complete stroke length. For this reason, the user cannot adjust an adjustment of the manufacturer. If the measuring results are outside of the manufacturer thresholds, the pipette is defective and should be sent to an authorized service.

10.1.1 Checking the reasons for a dispensing deviation

All external influencing factors must be ruled out before a pipette is adjusted.

- The tip cone is OK
- The pipette tip is compatible with the pipette
- The dispensing system is leak-tight (pipette and pipette tip)
- Test liquid was aspirated and dispensed 5 times (saturated air cushion)
- The test liquid, dispenser and ambient air have the same temperature
- The test liquid meets the ISO 3696 requirements
- Immersion depth during liquid aspiration complied with
- Liquid dispensing against the tube inner wall
- Pipetting speed is set correctly
- The balance resolution matches the testing volume
- No draft at weighing location
- Evaluation of measuring results performed correctly

▶ Decide if an adjustment is required.

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

The dispenser can also be sent to the authorized service for adjustment.

10.2 Adjusting in case of deviating conditions

The physical properties of liquids and the ambient conditions are significant influencing factors for piston-stroke pipettes. Mechanical and electronic pipettes can be adjusted to these conditions.

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).

Index

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