eppendorf

Standard Operating Procedure

Standard Testing Procedure for Manual Dispensing Systems

ASOP P39 020-16/2025-12

Table of contents

1 Introduction

This standard testing procedure summarizes the test station requirements, the necessary preparations, performing the test series, and evaluating the measuring results required for calibrating a manual dispensing device (mechanical and electronic).

The first step is to service the dispensing device (e.g., cleaning). To maintain the clarity of this document, reference is made to the relevant operating manuals in the case of product-specific information. The leakage test indicates whether the dispensing system is leak-tight or not. However, it does not provide information about the actual performance of the pipette and therefore does not replace a general calibration check.

The next step is to test the device, i.e., calibration. This test is based on the specifications in the DIN EN ISO 8655-6:2022 standard for gravimetric testing.

For pipettes, a further step may follow: If calibration reveals that the pipette is not operating within the specified maximum permissible errors, the device can be adjusted. Adjustment may be performed only if errors due to handling, the system, or the test equipment have been ruled out.

2 About this manual

2.1 Version overview

Version	Change	Date
16	• Research 3 neo mechanical single-channel pipette with adjustable volume added • Chapters added: – Notes on this manual – Structure of a warning – Graphic elements – Other applicable documents – Suitable cleaning agents and disinfectants • Editorial adjustments to the chapter structure	2025-12
15	• General module for copyright and disclaimer used • Adjustments to the new version of the DIN EN ISO 8655-6:2022 standard	2023-04
14	• Error of measurements for Reference 2: Table for special tips deleted • Error of measurements for Eppendorf Research plus: Table for special tips deleted • Eppendorf AG changed to Eppendorf SE	2022-04
13	• Corrections to error of measurements for the Move It multi-channel pipette	2021-07
12	• Editorial changes and corrections • Eppendorf Reference, Eppendorf Research, Eppendorf Research pro, and Multipette/Repeater pipette models removed • Move It multi-channel pipette added • Varispenser 2/2x dispenser added	2021-04

Version	Change	Date
11	• Introduction expanded to include 16- and 24-channel pipettes • Calibration instructions for 16- and 24-channel pipettes added • Calibration instructions for multi-channel pipettes clarified • Correction of measured value deviations for Multipette M4 and Multipette E3/E3x • Measured value deviations supplemented with new volume models (Research plus and Xplorer plus) • New tables for measured value deviations of the 16-/24-channel pipettes added (Eppendorf Research plus and Eppendorf Xplorer/Eppendorf Xplorer plus) • Editorial text corrections	2019-05
10	• Chapter structure and content completely revised and updated • Gravimetric testing of positive displacement pipettes with 30 measured values added • Product-specific information on cleaning, maintenance, autoclaving, and adjustment removed. Reference made to the relevant operating manual. • Calculation errors corrected • Formulas cleaned up • Flowcharts for calibration procedure added • Multipette E3/E3x –Repeater E3/E3x added • Leakage test adapted to current pipettes • Glossary expanded • Title and cover photo changed	2016-04
09	• Document number updated	2014-01
08	• Reference 2 pipette added	2013-05
07	• Design change	2013-04
01 – 06	• Document control without change history	–

2.2 Purpose and scope

Purpose

This standard testing procedure summarizes the requirements and tasks necessary for calibrating a manual dispensing device (mechanical and electronic):

- Test station requirements
- Necessary preparations
- Performance of tests series
- Evaluation of measuring results

2.3 Notes on this manual

The dates in this manual correspond to the international date format as specified in the ISO 8601 standard. All dates are shown in the format YYYY-MM-DD or YYYY-MM.

1. Read this manual completely before using the product.
2. Please ensure that you have the manual available while using the product.

The current version of the manual can be found at www.eppendorf.com/manuals.
- Contact Eppendorf SE to obtain another version of the manual.

2.4 Warning notice structure

HAZARD LEVEL! Type of danger

Source of danger
Consequences of disregarding the danger

– Measures to avoid the danger

Symbol	Hazard level	Type of danger	Meaning
	DANGER	Personal injury	Will lead to severe injuries or death.
	WARNING	Personal injury	May lead to severe injuries or death.
	CAUTION	Personal injury	May lead to minor or moderate injuries.
	NOTICE	Material damage	May lead to material damage.

2.5 Graphics

Depiction	Meaning
1. 2.	Work steps
•	Bullet point
Text	Display text
Key	Name for port, button, status lamp, or key
	Important information
	Tip

2.6 Other applicable documents

The following documents supplement the manual:

- Operating manual for the corresponding dispensing device
- Instructions for use for the epT.I.P.S. pipette tips
- Instructions for use for the epT.I.P.S. 384 pipette tips
- Instructions for use for the epT.I.P.S. Box 2.0 reusable box
- "Grease for pipettes" instructions for use
- The Science of Pipetting to Perfection - A guide to expert pipetting
  Free eBook download: https://www.eppendorf.link/pipetting-ebook

2.7 Supported dispensing devices

Supported dispensing devices from Eppendorf

The standard testing procedure can be used for the following dispensing devices:

Mechanical piston-stroke pipettes – air cushion principle

- Eppendorf Research 3 neo
- Eppendorf Research plus
- Reference 2

Electronic piston-stroke pipettes – air cushion principle

- Eppendorf Xplorer
- Eppendorf Xplorer plus

Mechanical piston-stroke pipettes – hybrid system

- Varipette + Varitips S-System – air cushion principle
- Maxipettor + Maxitip S-System – air cushion principle
- Varipette + Varitips P – positive displacement principle
- Maxipettor + Maxitip P – positive displacement principle

Mechanical piston-stroke pipettes – positive displacement principle

- Biomaster

Mechanical multi-dispensers – positive displacement principle

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

Electronic multi-dispensers – positive displacement principle

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

Mechanical single stroke dispensers – positive displacement principle

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

Mechanical bottle top burettes – positive displacement principle

- Top Buret M
- Top Buret H

3 Maintenance

Regular cleaning and maintenance of the dispensing devices ensures compliance with the specified error of measurements. The frequency of cleaning and maintenance of each dispensing device depends on the intensity of use and the chemicals being dispensed. Shorter cleaning intervals are recommended for intensive use or when dispensing aggressive chemicals.

Eppendorf SE recommends creating a maintenance book for the dispensing devices or recording maintenance details in the calibration protocol.

Eppendorf SE recommends sending the device to an Eppendorf SE-certified service organization for maintenance.

Information on cleaning, care, maintenance, sterilization, and disinfection can be found in the operating manual for the respective dispensing devices. The instructions given in the "Maintenance" chapter in the operating manual for the respective dispensing device must be followed.

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

Perform cleaning and maintenance before calibration.

Exception: If you need to record the current state of dispensing devices to draw conclusions about analytical results, performing calibration before maintenance may be useful. In this case, perform a second calibration after cleaning/maintenance.

3.1 Suitable cleaning agents and disinfectants

In the tables you will find suitable cleaning agents and disinfectants for various types of contamination.

Cleaning agents

Contamination	Suitable cleaning agents
Water-soluble contamination: • Acids • Alkalis • Saline solutions	• Deionized water
Molecular biological contamination: • Nucleic acids	• DNA/RNA cleaning agent • Sodium hypochlorite, maximum 4 %
Biochemical contamination: • Proteins	• Mild detergent

Disinfectants

Contamination	Suitable disinfectants
• Infectious liquids • Microorganisms	• Ethanol 70 % • Isopropanol • Meliseptol

3.2 Cleaning piston-stroke pipettes – air cushion principle

Cleaning and disinfecting the lower part

NOTICE! Damage to the device and accessories

The use of unsuitable cleaning agents or sharp objects may damage the device and its accessories.

– Do not use any aggressive cleaning agents, strong solvents or abrasive polishes.
– Check the compatibility with the materials used.
– Do not clean the device with acetone or organic solvents with a similar effect.
– Do not use any sharp or pointed objects to clean the device.

Material:

- Soap-based cleaning agent
- Deionized water
- Decontamination agent
- Pipette grease

Prerequisites:

- Heavy contamination caused by ingress of liquid has been removed.
- The lower part has been removed and disassembled.

1. Remove the piston grease.
2. Rinse the lower part with cleaning agent or decontamination agent, or immerse the lower part in cleaning agent or decontamination agent. Observe the manufacturer's instructions for the contact time of the cleaning agent and decontamination agent.
3. Rinse the lower part thoroughly with purified water.
4. Let the lower part dry.
5. Grease the piston and cylinder. Refer to the "Grease for Pipettes" instructions for use.
6. Reassemble the lower part.

3.3 Cleaning piston-stroke pipettes – positive displacement principle

In piston-stroke pipettes with a positive displacement system, the piston is integrated into the pipette tip. This design feature protects the internal components of the pipette from contamination.

NOTICE! Damage to the device and accessories

The use of unsuitable cleaning agents or sharp objects may damage the device and its accessories.

- Do not use any aggressive cleaning agents, strong solvents or abrasive polishes.
- Check the compatibility with the materials used.
- Do not clean the device with acetone or organic solvents with a similar effect.
- Do not use any sharp or pointed objects to clean the device.

Material:

- Soap-based cleaning agent
- Deionized water
- Cloth

1. Moisten a lint-free cloth with water and cleaning agent.
2. Clean the outside of the pipette with the damp cloth.

3.4 Cleaning multi-dispensers – positive displacement principle

In multi-dispensers, the piston is integrated into the dispenser tip. This design feature protects the internal components of the multi-dispenser from contamination.

NOTICE! Damage to the device and accessories

The use of unsuitable cleaning agents or sharp objects may damage the device and its accessories.

- Do not use any aggressive cleaning agents, strong solvents or abrasive polishes.
- Check the compatibility with the materials used.
- Do not clean the device with acetone or organic solvents with a similar effect.
- Do not use any sharp or pointed objects to clean the device.

Material:

- Soap-based cleaning agent
- Deionized water
- Cloth

1. Moisten a lint-free cloth with water and cleaning agent.
2. Clean the outside of the dispenser with the damp cloth.

3.5 Cleaning single stroke dispensers

Single stroke dispensers must be cleaned on the outside and inside.

Cleaning the outside of a single stroke dispenser

NOTICE! Damage to the device and accessories

The use of unsuitable cleaning agents or sharp objects may damage the device and its accessories.

- Do not use any aggressive cleaning agents, strong solvents or abrasive polishes.
- Check the compatibility with the materials used.
- Do not clean the device with acetone or organic solvents with a similar effect.
- Do not use any sharp or pointed objects to clean the device.

Material:

- Soap-based cleaning agent
- Deionized water

- Cloth

1. Moisten a lint-free cloth with water and cleaning agent.
2. Clean the outside of the housing with the damp cloth.

Cleaning the inside of a single stroke dispenser

Material:

- pH-neutral soap
- Deionized water

1. Rinse the tubing and piston system several times with a neutral cleaning solution.
2. Rinse the tubing and piston system several times with purified water.

3.6 Cleaning bottle top burettes

With bottle top burettes, the piston comes into direct contact with the liquid to be dispensed. The dispensing device must therefore be cleaned on the outside and inside. The Top Buret is not autoclavable.

Cleaning the outside of a bottle top burette

NOTICE! Damage to the device and accessories

The use of unsuitable cleaning agents or sharp objects may damage the device and its accessories.

- Do not use any aggressive cleaning agents, strong solvents or abrasive polishes.
- Check the compatibility with the materials used.
- Do not clean the device with acetone or organic solvents with a similar effect.
- Do not use any sharp or pointed objects to clean the device.

Material:

- Soap-based cleaning agent
- Deionized water
- Cloth

1. Moisten a lint-free cloth with water and cleaning agent.
2. Clean the outside of the housing with the damp cloth.

Cleaning the inside of a bottle top burette

Material:

- pH-neutral soap
- Deionized water

1. Rinse the tubing and piston system several times with a neutral cleaning solution.
2. Rinse the tubing and piston system several times with purified water.
3. Check for leaks.

3.7 Shipping a manual dispensing device

WARNING! Contamination

Shipping or storing a contaminated pipette may lead to contamination of persons or cause damage to health.

– Clean and decontaminate the pipette before shipping it or putting it into storage.

Prerequisites:

- The manual dispensing device has been cleaned and decontaminated.

1. Download the decontamination certificate for returned goods from the website: https://www.eppendorf.link/decontamination/.
2. Complete the decontamination certificate.
3. Pack the manual dispensing device securely to prevent damage during shipping.
4. Attach the decontamination certificate to the outside of the packing in a way that ensures it will not be damaged during transport.
5. Ship the manual dispensing device.

4 Test intervals

The change in systematic and random errors is a gradual process. It is accelerated in particular by aggressive chemicals. There is no general rule or calculation basis for determining meaningful intervals.

Calibration results documented over a longer period of time allow conclusions to be drawn about an individual calibration frequency.

Test intervals may be specified by laboratory regulations. DIN EN ISO 8655 requires annual calibration.

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

- Frequency of use
- Accuracy requirements for the dispensing device
- Handling
- Chemicals
- Laboratory regulations

5 Types of testing

There are various ways to test a dispensing system. The simplest and most common test is a visual inspection of the dispensing device for damage and contamination. The individual types of testing are described in the following chapters.

Eppendorf SE recommends performing calibration according to the gravimetric reference procedure. This procedure is described in DIN EN ISO 8655-6:2022.

5.1 Performing a visual inspection of all dispensing devices

1. Examine the tip cone for scratches or cracks.
2. Inspect the dispensing device for broken parts.
3. Inspect the dispensing device for external contamination.
4. Check the piston free movement.

5.2 Performing a visual inspection of single stroke dispensers and bottle top burettes

1. Replace the liquid if it has crystallized.
2. Clean the dispensing device.
3. If air bubbles are present in the system: Vent the system.

5.3 Checking the leak tightness of dispensing devices with air cushion principle

Performing a leak test

Prerequisites:

- The ambient temperature is constant.
- The ambient temperature is between 20 °C – 25 °C.
- The dispensing device, the test tip, and test liquid are at ambient temperature or have been cooled to ambient temperature.
- The relative humidity is above 50 %.
- The epT.I.P.S. pipette tips are available as test tips.
- Demineralized water is available as test liquid.

1. Set the dispensing device to the nominal volume.
2. Attach a pipette tip.

3. Fill and empty the pipette tip with test liquid 5 times.

   This ensures saturation of the vapor phase in the air cushion and prevents further evaporation of the test liquid.

4. Aspirate the nominal volume once.

5. Hang the dispensing device vertically in a holder and wait 15 s.

   

   You can also hold the dispensing device vertically with two fingers. It is important that the warmth of your hand is not transferred to the pipette.

   Leak-tight: If within 15 s **no** liquid droplet forms at the pipette tip, the dispensing system is leak-tight.
   Not leak-tight: If within 15 s a liquid droplet forms at the pipette tip, the dispensing system is not leak-tight.

Sealing a leaking dispensing system

1. Check the assembly of the dispensing device.
2. Check the piston seal for damage.
3. If the piston seal is damaged: Replace the piston with seal.
4. Repeat the leak test.

5.4 Checking the leak tightness of dispensing devices with positive displacement principle

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

In single stroke dispensers and bottle top burettes, air in the tubing system indicates a leak in the piston/cylinder system. The leak can be caused by crystallization, defective seals, a defect in the piston system or the cylinder system.

1. Remove any crystallization from the dispensing device.
2. If the cleaned dispensing device continues to leak: Send the dispensing device to an authorized service center.

5.5 Conformity testing

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

The conformity test verifies whether a dispensing system operates within the specified measurement tolerances. This involves performing a calibration with 10 measured values per volume. The user can freely determine the thresholds within the ISO thresholds. Calibration laboratories routinely test against manufacturer thresholds and thus assess conformity with these thresholds.

6 Conditions for gravimetric testing

To avoid distorting the measuring results, prevent errors in the test equipment and test procedures.

6.1 Measuring station setup

A fully equipped measuring station consists of the following components:

- Analytical balance for single-channel pipettes
- Analytical balance with multiple load cells for multi-channel pipettes
- Evaporation protection (e.g., evaporation trap)
- Thermometer liquid (0.2 K)
- Thermometer air (0.3 K)
- Hygrometer (5 %)
- Barometer (±1 kPa)
- Stopwatch (1 s)
- Reservoir for test liquid
- Test liquid (demineralized water)
- Test tips

Analytical balance

The analytical balance must meet the following requirements:

- The balance operates within the specified weighing tolerances.
- The weighing result is displayed quickly and reliably.
- The balance resolution is appropriate for the testing volume.

Single-channel balance

Nominal volume of dispensing device	Resolution of 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

Multi-channel balance

Nominal volume of dispensing device	Resolution of 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

Liquid reservoir

Select a reservoir that can hold all the liquid required for the upcoming test.

Weighing vessel

Leading balance manufacturers offer special weighing vessels and evaporation protection (e.g., evaporation traps) for the gravimetric testing of pipettes. The use of such equipment leads to stable weight readings. Measurement errors caused by evaporation are significantly reduced, especially with small volumes.

The weighing vessel should meet the following requirements:

- Sealable
- Size appropriate for the testing volume
- Height-to-diameter ratio of at least 3:1

Measuring station

The measuring station should meet the following requirements:

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

6.2 Test liquid

Use distilled or purified water that complies with ISO 3696:1991-06. The water temperature must not deviate by more than ±0.5 °C from the ambient air temperature.

6.3 Temperature

The test room and all materials required for calibration must be at the reference temperature of 20 °C (±3 °C) for 2 hours prior to the start of 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.

6.4 Test tips

Test all Eppendorf SE pipettes and dispensers with original Eppendorf SE consumables, pipette tips, or dispensing tips .

The correct combinations are shown in the table below.

Pipette/dispenser	Consumable
All piston-stroke pipettes	epT.I.P.S.
Biomaster	Mastertip
Maxipettor	Maxitip P or Maxitip S-System
Multipette/Repeater	Combitips advanced
Varipette	Varitips P or Varitips S-System

6.5 Data transfer and data evaluation

You can use calibration software to automatically record the gravimetrically obtained measured values, convert the measured values into corrected volumes, and calculate errors of measurements from these values.

6.6 Further test conditions

Keep the test cycle duration (time required to weigh a dispensed volume) as short as possible and consistent from cycle to cycle. For all of the dispensing devices mentioned, testing is performed by determining the dispensing volume in the weighing vessel (Ex).

7 Calibration

7.1 Calibration process flow

Calibration involves various steps, which are described in this SOP. The following diagram provides an overview of the individual steps.

Symbol	Meaning
	Beginning or end of the process.
	A single action or sequence of actions within the process.
	A branching point or decision within the process.

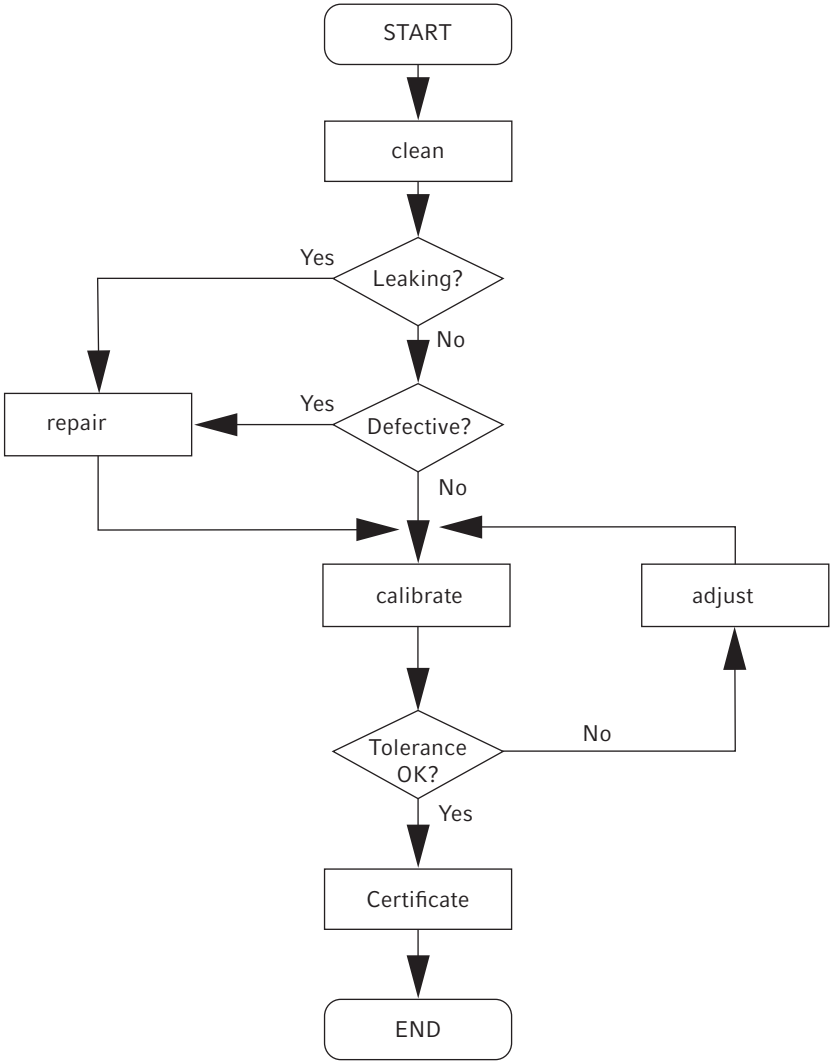

Fig. 7-1: Overall calibration process

7.2 Calibration procedure in the device groups

The calibration process differs between the device groups. The following process diagram illustrates this.

All pipettes are calibrated in forward pipetting mode.

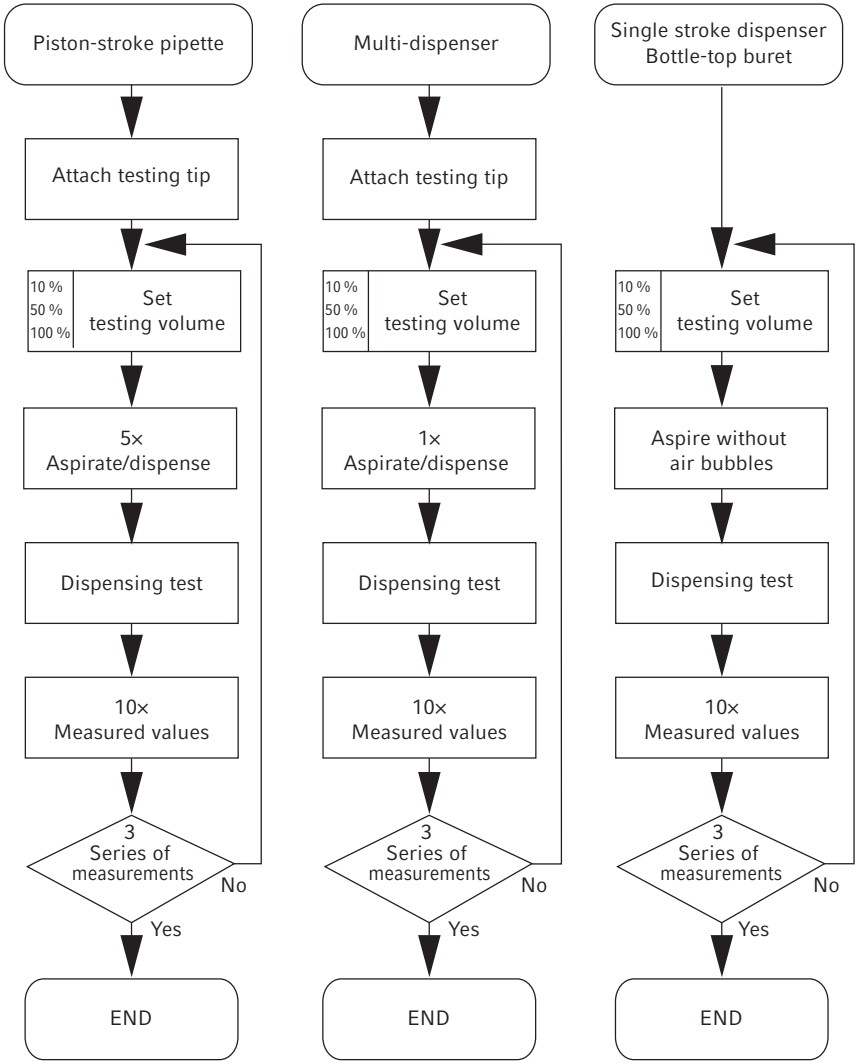

Fig. 7-2: Calibration procedure of the individual device groups

7.3 Requirements for a calibration process

Collection of a series of measurements

Determine the measured values of a series of measurements consecutively over time. This reduces the risk of errors or deviations between the measured values.

Number of measured values to be collected

Single-channel pipettes with variable volume	Multi-channel pipettes
10 measured values per testing volume	10 measured values per channel for each testing volume

Pipette tip change scheme in the series of measurements

Use new pipette tips during the series of measurements according to the following scheme:

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	1	2	3	4	5	6	7	8	9	10
Series of measurements 1										Series of measurements 2										Series of measurements 3									

Number of testing volumes

For pipettes with variable volume, test the following volumes in the order listed:

- 10 % of the nominal volume or the smallest adjustable volume (choose the larger of the two volumes)
- 50 % of the nominal volume
- 100 % of the nominal volume

or

- Optional: A freely selectable testing volume, e.g., as required by a laboratory procedure

Pipette tip immersion depths and waiting times for liquid aspiration

Volume in µL	**Immersion depth in mm**	**Waiting time in s**
≤ 1	1 – 2	1
> 1 – 100	2 – 3	1
> 100 – 1000	2 – 4	1
> 1000 – 20000	3 – 6	3

7.4 Preparing the calibration

7.4.1 Preparing the dispensing device, test liquid, and analytical balance

Prerequisites:

- The dispensing device has been cleaned.
- Defective dispensing device parts have been replaced.
- The dispensing device has been decontaminated and disinfected.

1. Fill the test liquid.
2. Place the dispensing device and pipette tips at the measuring station.
3. Allow the dispensing device, pipette tips, and test liquid to acclimatize in the test room for at least 2 h.

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

1. For test run I, equip all odd-numbered rows in the reusable box with pipette tips.
2. For test run II, equip all even-numbered rows in the reusable box with pipette tips.

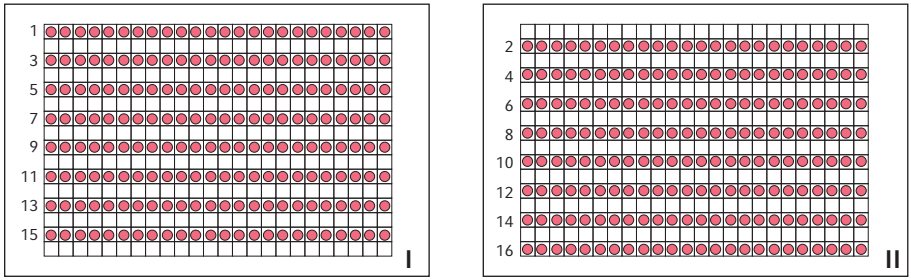

Fig. 7-3: Reusable boxes for test runs I and II

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

1. For test run I, equip all odd-numbered columns in the reusable box with pipette tips.
2. For test run II, equip all even-numbered columns in the reusable box with pipette tips.

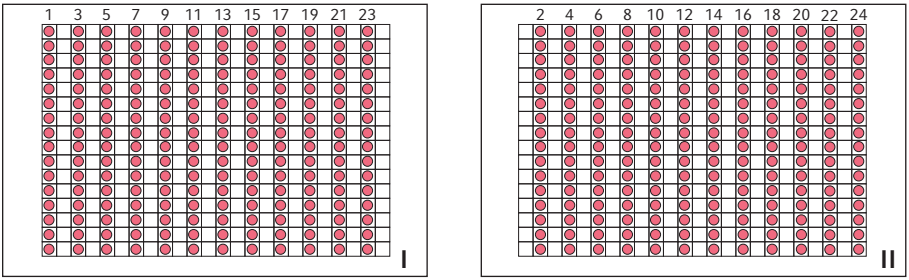

Fig. 7-4: Reusable boxes for test runs I and II

7.4.4 Preparing the documentation

1. Print the checklist.
2. Print the test report or prepare an Excel list.
3. Start the calibration software.

7.4.5 Preparing the calibration checklists

Use the following checklists during preparation. This will ensure that all necessary equipment is available at the time of calibration.

The checklist is divided into the following sections:

- A – Test conditions
- B – Test liquid
- C – Dispensing device
- D – Analytical balance
- E – Calibration software

A – Test conditions

Number	Description	Yes	No
A01	A vibration-free weighing table is available.		
A02	The dispensing device, pipette tips, test liquid, etc., are at ambient temperature.		
A03	The measuring station is free from drafts.		

Number	Description	Yes	No
A04	The ambient temperature is between 17 °C and 30 °C.		
A05	The relative humidity is between 45 % and 80 %.		
A06	The temperature, humidity, and atmospheric pressure are documented.		
A07	The tester is able to operate the dispensing device.		
A08	The test data (name of the tester, date, etc.) is documented.		
A09	The testing procedure is specified (manufacturer's specifications, ISO, laboratory standard, etc.).		
A10	The liquid is dispensed into the weighing vessel (Ex).		

B – Test liquid

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

C – Dispensing device

Number	Description	Yes	No	Not available
C01	The dispensing device has been cleaned.			
C02	Defective components have been replaced.			
C03	Electronic dispensing device: The rechargeable battery is charged.			
C04	Electronic multi-dispenser: Dispensing mode is selected.			
C05	Electronic pipette: Pipetting mode is selected.			
C06	Mechanical dispenser: The nominal volume has been determined.			
C07	Dispensing system with variable volume: The testing volume has been set.			
C08	Piston-stroke pipette: The pipette tip is correctly attached.			
C09	Multi-dispenser: The dispenser tip is correctly inserted.			
C10	The device has been in the calibration laboratory for at least 2 h for acclimatization.			

D – Analytical balance

Number	Description	Yes	No
D01	The balance is horizontally aligned.		
D02	The balance is calibrated or a valid calibration certificate is available.		
D03	The sensitivity is set according to the testing volume.		
D04	The weighing vessel volume is sufficient for 10 liquid dispensing operations of the nominal volume.		
D05	The balance was switched on at least 2 h before calibration.		

E – Calibration software

Number	Description	Yes	No	Not available
E 01	The computer is switched on and connected to the analytical balance.			
E 02	The calibration software can record the measured values.			
E 03	The calibration software and the analytical balance are ready to communicate.			

7.5 Performing calibration

7.5.1 Pre-saturating the air cushion

For air-cushion pipettes

1. Aspirate the test liquid 5 times and dispense it again.
   This minimizes evaporation and reduces measurement errors.

For positive displacement pipettes and multi-dispensers

1. Aspirate the test liquid 1 time and dispense it again.
   This minimizes the air bubble that has been aspirated.

For single-dispensers and burettes

1. Fill the dispensing device until the system is free of air bubbles.

7.5.2 Determining measured values – mechanical single-channel pipettes

Prerequisites:

- The test tip is attached.

1. Set the testing volume.
2. Aspirate the test liquid 5 times and dispense it again.
3. Immerse the test tip vertically into the test liquid.
4. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
5. Wait until the liquid has been aspirated.

6. Withdraw the test tip from the liquid.
7. Place the test tip at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
8. Perform a test dispensing.
9. Determine the measured values for each testing volume.

7.5.3 Determining measured values – mechanical multi-channel pipettes with 4.5 mm cone spacing

For multi-channel pipettes with a cone spacing of 4.5 mm, you must determine the measured values for a testing volume in two test runs. The minimum distance between two load cells is 9 mm. Due to technical reasons, only every second channel can be measured in a test run.

In test run I, measure all channels with odd numbers. In test run II, measure all channels with even numbers.

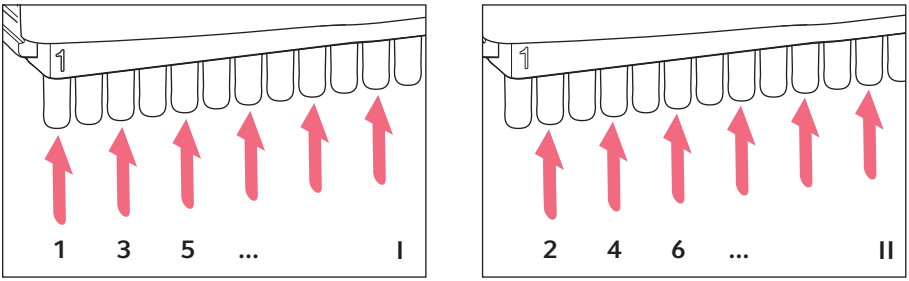

Fig. 7-5: Equipping the tip cones for test runs I and II

Prerequisites:

- A reusable box with pipette tips for test run I is prepared.
- A reusable box with pipette tips for test run II is prepared.

1. Attach the pipette tips for test run I.
2. Set the testing volume.
3. Aspirate the test liquid 5 times and dispense it again.
4. Immerse the test tips vertically into the test liquid.
5. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
6. Wait until the liquid has been aspirated.

7. Withdraw the test tips from the liquid.
8. Place the test tips at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
9. Perform a test dispensing.
10. Determine the measured values for the testing volume.
11. Discard the test tips.
12. Attach the pipette tips for test run II.
13. Aspirate the test liquid 5 times and dispense it again.
14. Immerse the test tips vertically into the test liquid.
15. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
16. Wait until the liquid has been aspirated.
17. Withdraw the test tips from the liquid.
18. Position the test tips at an angle of 30° – 45° against the inner wall of the weighing vessel.
19. Perform a test dispensing.
20. Determine the measured values for the testing volume.
21. Determine the measured values for each testing volume with test runs I and II.

7.5.4 Determining measured values – mechanical multi-channel pipettes with 9 mm cone spacing

Prerequisites:

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

1. Set the testing volume.
2. Aspirate the test liquid 5 times and dispense it again.
3. Immerse the test tips vertically into the test liquid.
4. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
5. Wait until the liquid has been aspirated.
6. Withdraw the test tips from the liquid.
7. Place the test tips at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.

8. Perform a test dispensing.
9. Determine the measured values for each testing volume.

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

Prerequisites:

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

1. Set the cone spacing to 9 mm.
2. Set the testing volume.
3. Aspirate the test liquid 5 times and dispense it again.
4. Immerse the test tips vertically into the test liquid.
5. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
6. Wait until the liquid has been aspirated.
7. Withdraw the test tips from the liquid.
8. Place the test tips at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
9. Perform a test dispensing.
10. Determine the measured values for each testing volume.

7.5.6 Determining measured values – electronic single-channel pipettes

1. Set the aspiration speed and dispensing speed.
   ↳ *Chapter 8.1 "Test conditions" on page 56*
2. Set the operating mode.
   ↳ *Chapter 8.1 "Test conditions" on page 56*
3. Attach the test tip.
4. Set the testing volume.
5. Aspirate the test liquid 5 times and dispense it again.
6. Immerse the test tip vertically into the test liquid.
7. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
8. Wait until the liquid has been aspirated.
9. Withdraw the test tip from the liquid.

10. Position the test tip at an angle of 30° – 45° against the inner wall of the weighing vessel.
11. Dispense the liquid onto the vessel inner wall.
12. Determine the measured values for each testing volume.

7.5.7 Determining measured values – electronic multi-channel pipettes with 4.5 mm cone spacing

For multi-channel pipettes with a cone spacing of 4.5 mm, you must determine the measured values for a testing volume in two test runs. The minimum distance between two load cells is 9 mm. Due to technical reasons, only every second channel can be measured in a test run.

In test run I, measure all channels with odd numbers. In test run II, measure all channels with even numbers.

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.

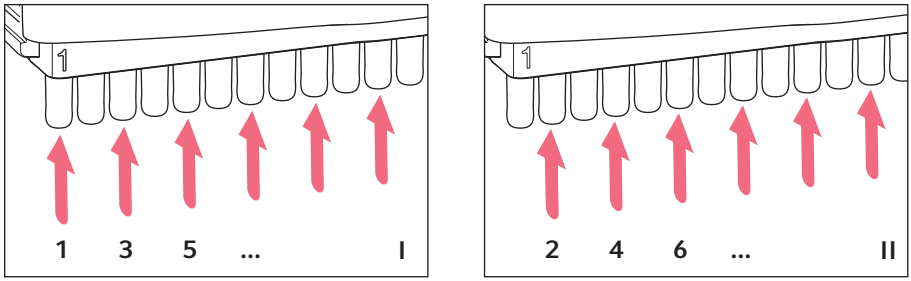

Fig. 7-6: Equipping the tip cones for test runs I and II

Prerequisites:

- A reusable box with pipette tips for test run I is prepared.
- A reusable box with pipette tips for test run II is prepared.

1. Attach the pipette tips for test run I.
2. Set the aspiration speed and dispensing speed.
   ↳ *Chapter 8.1 “Test conditions” on page 56*
3. Set the operating mode.
   ↳ *Chapter 8.1 “Test conditions” on page 56*
4. Set the testing volume.

5. Aspirate the test liquid 5 times and dispense it again.
6. Immerse the test tips vertically into the test liquid.
7. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
8. Wait until the liquid has been aspirated.
9. Slowly withdraw the test tips from the liquid.
10. Place the test tips at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
11. Perform a test dispensing.
12. Determine the measured values for the testing volume.
13. Discard the pipette tips.
14. Attach the pipette tips for test run II.
15. Aspirate the test liquid 5 times and dispense it again.
16. Immerse the test tips vertically into the test liquid.
17. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
18. Wait until the liquid has been aspirated.
19. Slowly withdraw the test tips from the liquid.
20. Place the test tips at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
21. Perform a test dispensing.
22. Determine the measured values for the testing volume.
23. Determine the measured values for each testing volume with test runs I and II.

7.5.8 Determining measured values – electronic multi-channel pipettes with 9 mm cone spacing

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.

Prerequisites:

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

1. Set the aspiration speed and dispensing speed.
   ↳ *Chapter 8.1 "Test conditions" on page 56*
2. Set the operating mode.
   ↳ *Chapter 8.1 "Test conditions" on page 56*
3. Set the testing volume.
4. Aspirate the test liquid 5 times and dispense it again.
5. Immerse the test tips vertically into the test liquid.
6. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
7. Wait until the liquid has been aspirated.
8. Slowly withdraw the test tips from the liquid.
9. Place the test tips at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
10. Perform a test dispensing.
11. Determine the measured values for each testing volume.

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

Prerequisites:

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

1. Set the cone spacing to 9 mm.
2. Set the aspiration speed and dispensing speed.
   ↳ *Chapter 8.1 "Test conditions" on page 56*
3. Set the operating mode.
   ↳ *Chapter 8.1 "Test conditions" on page 56*
4. Set the testing volume.
5. Aspirate the test liquid 5 times and dispense it again.
6. Immerse the test tips vertically into the test liquid.
7. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
8. Wait until the liquid has been aspirated.
9. Slowly withdraw the test tips from the liquid.

10. Place the test tips at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
11. Perform a test dispensing.
12. Determine the measured values for each testing volume.

7.5.10 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, you must determine the measured values according to the procedure for mechanical single-channel pipettes or according to the procedure for mechanical multi-dispensers.

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

1. Attach the test tip.
2. Set the testing volume.
3. Perform the number of pre-saturating steps according to the test tip used.
4. Perform a test dispensing.
5. Determine the measured values for each testing volume.

7.5.11 Determining measured values – mechanical multi-dispensers

Eppendorf SE recommends using the 5 mL Combitips advanced as the quality control results of a new multi-dispenser are based on these Combitips. However, you can also use any other Combitips advanced for calibration. Eppendorf SE specifies maximum permissible errors for all Combitips advanced.

- Selection dial position 1 corresponds to 10 % of the nominal volume.
- Selection dial position 5 corresponds to 50 % of the nominal volume.
- Selection dial position 10 corresponds to 100 % of the nominal volume.

1. Attach the test tip.
2. Aspirate the test liquid 1 time and dispense it again.
3. Set the testing volume.
4. Immerse the test tips vertically into the test liquid.
5. Maintain the immersion depth and aspirate the test liquid slowly and evenly.

6. Wait until the liquid has been aspirated.
7. Slowly withdraw the test tips from the liquid.
8. Position the test tip at an angle of 30° – 45° against the inner wall of the weighing vessel.
9. Perform a test dispensing.
10. Determine the measured values for each testing volume.

7.5.12 Determining measured values – electronic multi-dispensers

Eppendorf SE recommends using the 5 mL Combitips advanced as the quality control results of a new multi-dispenser are based on these Combitips. However, you can also use any other Combitips advanced for calibration. Eppendorf SE specifies maximum permissible errors for all Combitips advanced.

1. Set the *Dis* operating mode.
2. Attach the test tip.
3. Aspirate the test liquid 1 time and dispense it again.
4. Set the testing volume.
5. Immerse the test tips vertically into the test liquid.
6. Maintain the immersion depth and aspirate the test liquid slowly and evenly.
7. Wait until the liquid has been aspirated.
8. Slowly withdraw the test tips from the liquid.
9. Place the test tip of the channel to be tested at an angle of 30° – 45° against the vessel inner wall of the weighing vessel.
10. Perform a test dispensing.
11. Determine the measured values for each testing volume.

7.5.13 Determining measured values – mechanical single stroke dispensers

1. Place the beaker on the analytical balance.
2. Set the testing volume.
3. Aspirate the test liquid without air bubbles.
4. Perform a test dispensing.
5. Determine the measured values for each testing volume.

7.5.14 Determining measured values – mechanical bottle top burette

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

7.6 Evaluating the calibration

To determine the performance of dispensing devices, the systematic and random errors are determined. A conclusion can only be drawn from the combination of both errors of measurements.

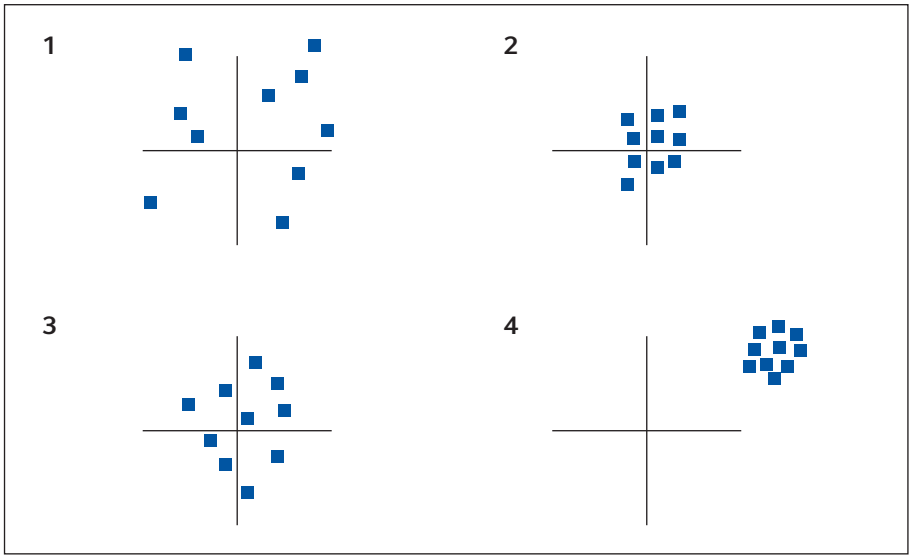

Fig. 7-7: Distribution of measured values

1	Poor precision and accuracy	3	Poor precision, good accuracy
2	Good precision and accuracy	4	Good precision, poor accuracy

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

- Convert the mass value to volume.
- Calculate the average value of the measured volume values.
- Calculate the systematic and random errors.

7.6.1 Converting gravimetric measured values to volume

You must convert the gravimetrically determined measured values into volume values. The correction factor Z takes into account the density of water depending on temperature and atmospheric pressure.

$$V_i = m_i \cdot Z$$

Fig. 7-8: Conversion of the gravimetric measured value to volume

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

1. Multiply the gravimetric measured value by the correction factor Z. ↳ *Chapter 7.6.2 "Correction factor Z" on page 46*

   The result is the measured volume value.

7.6.2 Correction factor Z

Tabular overview of correction values for purified 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

Temperature in °C	Correction factor *Z* in µL/mg						
	800 hPa	**850 hPa**	**900 hPa**	**950 hPa**	**1000 hPa**	**1013 hPa**	**1050 hPa**
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

7.6.3 Calculating the arithmetic average volume value

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

Fig. 7-9: Calculation of the arithmetic average volume value

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

1. Divide the sum of the volume values by the number of measurements.
   The result is the arithmetic average of the volume values.

7.6.4 Calculating the systematic error

The systematic error is the measure of the deviation of the average volume value from the set value of the dispensed volume.

Calculating the absolute systematic error

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

Fig. 7-10: Calculation of the absolute systematic error

Formula symbol	Meaning
e_s	Absolute systematic error in µL
$\overline{V}$	Average volume value
V_s	Testing volume

1. Subtract the set testing volume from the average volume value.
   The result is the absolute error of measurement in volume.

Calculating the relative systematic error

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

Fig. 7-11: Calculation of the relative systematic error

Formula symbol	Meaning
$\overline{V}$	Average volume value
V_s	Testing volume
η_s	Relative systematic error in µL

1. Multiply the absolute error of measurement by 100.
2. Divide the result by the testing volume.
   The result is the relative error of measurement in percent.

7.6.5 Calculating the random error

The standard deviation is a measure of the scattering of individual values around the average volume value of the dispensed volume.

Calculating the absolute random error

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

Fig. 7-12: Calculation of the absolute random error

Formula symbol	Meaning
s_r	Repeatability standard deviation
n	Number of measurements
V_s	Testing volume
$\bar{V}$	Average volume value

1. Calculate the standard deviation of the volume value.
   The result is the absolute random error.

Calculating the relative random error

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

Fig. 7-13: Calculation of the relative random error

Formula symbol	Meaning
s_r	Repeatability standard deviation
$\bar{V}$	Average volume value
CV	Coefficient of variation

1. Multiply the absolute error of measurement by 100.
2. Divide the result by the average volume value.
   The result is the percentage random error.

7.6.6 Test report

Document the calibration results and all influencing factors. The following chapters specify the required contents of a test report.

Tester

Name	
First name	
Department	
Calibration date	

Dispensing device

Manufacturer	
Type	
Model number	
Nominal volume	
Serial number	

Test tip

Manufacturer	
Designation	

Analytical balance

Model	
Serial number	
Last calibration	

Adjustment

Basis of adjustment (Ex)	

Test conditions

Air temperature °C	
Atmospheric pressure hPa	
Relative humidity %	

Test procedure

DIN EN ISO 8655-6:2022 series of standards	
Laboratory procedure	
Manufacturer's specifications	
Other	

Series of measurements

Series of measurements 1										
Measured values										
					Actual value		Set value		Grade	
Average value $\overline{V}$										
Systematic error e_s										
Random error CV										
Comment										

Series of measurements 2										
Measured values										
					Actual value		Set value		Grade	
Average value $\overline{V}$										

Series of measurements 2			
Systematic error e_s			
Random error CV			
Comment			

Series of measurements 3										
Measured values										
					Actual value		Set value		Grade	
Average value $\overline{V}$										
Systematic error e_s										
Random error CV										
Comment										

Cleaning

Name	
First name	
Department	
Date	
Comment	

Maintenance

Name	
First name	
Department	
Date	
Parts replaced	
Comment	

8 Maximum permissible errors

8.1 Test conditions

Test conditions and test evaluation in accordance with DIN EN ISO 8655. Testing takes place using a certified analytical balance with evaporation protection.

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

8.2 Supplementary test conditions for Multipette E3/E3x

- Operating mode: *Dis*
- Testing with fully filled Combitips advanced
- Speed setting: 5

8.3 Supplementary test conditions for Multipette stream/Xstream

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

8.4 Supplementary test conditions for Eppendorf Xplorer/Eppendorf Xplorer plus

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

8.5 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
		10 µL	3.0	0.3	1.5	0.15
		20 µL	2.0	0.4	0.8	0.16

8.6 Multipette E3/E3x and 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

Test tip Combitips advanced	Volume range	Testing volume	Error of measurement			
			Systematic		Random	
			±%	±µL	%	µL
10 mL orange	0.1 mL – 10 mL	0.1 mL	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
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

8.7 Multipette–M4 and Repeater–M4 – 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	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

Test tip Combitips advanced	Volume range	Testing volume	Error of measurement			
			Systematic		Random	
			±%	±µL	%	µL
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
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 – 10 mL	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	10	0.25	25

8.8 Multipette 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

Test tip **Combitips advanced**	**Volume range**	**Testing volume**	**Error of measurement**			
			Systematic		**Random**	
			±%	**±µL**	**%**	**µL**
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

8.9 Reference 2 – error of measurement

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	2 µL – 200 µL yellow 53 mm	1.0	0.2	0.3	0.06
25 µL yellow	2 µL – 200 µL yellow 53 mm	1.0	0.25	0.3	0.075
50 µL yellow	2 µL – 200 µL yellow 53 mm	0.7	0.35	0.3	0.15

Model	Test tip epT.I.P.S.	Measurement error			
		Systematic		Random	
		±%	±µL	%	µL
100 µL yellow	2 µL – 200 µL yellow 53 mm	0.6	0.6	0.2	0.2
200 µL yellow	2 µL – 200 µL yellow 53 mm	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	50 µL – 1000 µL blue 71 mm	0.6	1.5	0.2	0.5
500 µL blue	50 µL – 1000 µL blue 71 mm	0.6	3.0	0.2	1.0
1000 µL blue	50 µL – 1000 µL blue 71 mm	0.6	6.0	0.2	2.0
2.0 mL red	0.25 mL – 2.5 mL red 115 mm	0.6	12	0.2	4
2.5 mL red		0.6	15	0.2	5

Reference 2 – single-channel pipettes 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	0.1	0.4	0.04
2 µL – 20 µL light gray	0.5 µL – 20 µL L 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	50 µL – 1000 µL	100 µL	3.0	3.0	0.6	0.6

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			Systematic		Random	
			±%	±µL	%	µL
blue	blue 71 mm	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	0.1 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

8.9.1 Reference 2 – 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	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

8.10 Eppendorf Research 3 neo – error of measurement

Eppendorf Research 3 neo – single-channel pipettes 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	24	0.024	10	0.01
		0.25 µL	12	0.03	6	0.015
		1.25 µL	2.5	0.031	1.5	0.01875
		2.5 µL	1.4	0.035	0.7	0.0175
0.5 µL – 10 µL medium gray	0.1 µL – 20 µL medium gray 40 mm	0.5 µL	8	0.04	5	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	0.1	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	0.1	1.5	0.03
		10 µL	1.2	0.12	0.6	0.06
		20 µL	1	0.2	0.3	0.06
1 µL – 20 µL yellow	2 µL – 200 µL yellow 53 mm	1 µL	10	0.1	3	0.03
		2 µL	5	0.1	1.5	0.03
		10 µL	1.2	0.12	0.6	0.06
		20 µL	1	0.2	0.3	0.06
5 µL – 100 µL yellow	2 µL – 200 µL yellow 53 mm	5 µL	6	0.3	2	0.1
		10 µL	3	0.3	1	0.1
		50 µL	1	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	1	0.3	0.3

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			Systematic		Random	
			±%	±µL	%	µL
		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	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	1.2	0.6
		100 µL	3	3	0.6	0.6
		500 µL	1	5	0.2	1
		1000 µL	0.6	6	0.2	2
0.1 mL – 2 mL red	0.25 mL – 2.5 mL red 115 mm	0.1 mL	5	5	1.4	1.4
		0.2 mL	3	6	1.2	2.4
		1.0 mL	0.8	8	0.2	2
		2.0 mL	0.5	10	0.2	4
0.25 mL – 5 mL violet	0.1 mL – 5 mL violet 120 mm	0.25 mL	4.8	12	1.2	3
		0.5 mL	2.4	12	0.6	3
		2.5 mL	0.8	20	0.25	6.25
		5.0 mL	0.6	30	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
		1.0 mL	3	30	0.6	6
		5.0 mL	0.8	40	0.2	10
		10.0 mL	0.6	60	0.15	15

8.11 Eppendorf Research plus – error of measurement

Eppendorf Research plus – single-channel pipettes 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 – 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	2 µL – 200 µL yellow 53 mm	1.0	0.2	0.3	0.06
25 µL yellow	2 µL – 200 µL yellow 53 mm	1.0	0.25	0.3	0.08
50 µL yellow	2 µL – 200 µL yellow 53 mm	0.7	0.35	0.3	0.15
100 µL yellow	2 µL – 200 µL yellow 53 mm	0.6	0.6	0.2	0.2
200 µL yellow	2 µL – 200 µL yellow 53 mm	0.6	1.2	0.2	0.4

Model	Test tip epT.I.P.S.	Error of measurement			
		Systematic		Random	
		±%	±µL	%	µL
200 µL ■ blue	50 µL – 1000 µL ■ blue 71 mm	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	50 µL – 1000 µL ■ blue 71 mm	0.6	3.0	0.2	1.0
1000 µL ■ blue	50 µL – 1000 µL ■ blue 71 mm	0.6	6.0	0.2	2.0

Eppendorf Research plus – single-channel pipettes 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	0.048	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 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	0.1	0.4	0.04
2 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
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	50 µL – 1000 µL	100 µL	3.0	3.0	0.6	0.6

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			Systematic		Random	
			±%	±µL	%	µL
blue	blue 71 mm	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	0.1 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

Eppendorf Research plus – multi-channel pipettes with fixed cone spacing

Model	Test tip epT.I.P.S. epT.I.P.S. 384	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	0.5 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
120 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

Eppendorf Research plus – multi-channel pipettes with adjustable cone spacing

Model	Test tip epT.I.P.S. epT.I.P.S. 384	Testing volume	Error of measurement			
			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	15 µL	7.4	1.1	2	0.3
		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	50 µL	14.5	7.25	2	1
		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

8.12 Top Buret M/H – error of measurement

Top Buret M

Model H	Testing volume	Error of measurement			
		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

Top Buret H

Model H	Testing volume	Error of measurement			
		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

8.13 Varipette and Maxipettor – error of measurement

Varipette

Model	Test tip	Testing volume	Error of measurement			
			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

Maxipettor

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	0.3	0.003
		5 mL	0.5	0.025	0.15	0.0075
		10 mL	0.3	0.03	0.1	0.01

8.14 Varispenser/Varispenser plus – error of measurement

Model	Testing volume	Error of measurement			
		Systematic		Random	
		±%	±µL	%	µL
0.5 mL – 2.5 mL	0.50 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	1.0 mL	2.5	0.025	0.5	0.0050
	2.5 mL	1.0	0.025	0.2	0.0050
	5.0 mL	0.5	0.025	0.1	0.0050
2 mL – 10 mL	2 mL	2.5	0.050	0.5	0.0100
	5 mL	1.0	0.050	0.2	0.0100
	10 mL	0.5	0.050	0.1	0.0100
5 mL – 25 mL	5.0 mL	2.5	0.125	0.5	0.0250
	12.5 mL	1.0	0.125	0.2	0.0250
	25.0 mL	0.5	0.125	0.1	0.0250
10 mL – 50 mL	10 mL	2.5	0.250	0.5	0.0500
	25 mL	1.0	0.250	0.2	0.0500
	50 mL	0.5	0.250	0.1	0.0500
20 mL – 100 mL	20 mL	2.5	0.500	0.5	0.1000
	50 mL	1.0	0.500	0.2	0.1000
	100 mL	0.5	0.500	0.1	0.1000

8.15 Varispenser 2/Varispenser 2x – error of measurement

Model	Testing volume	Error of measurement			
		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
	5.0 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 – 50 mL	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

8.16 Eppendorf Xplorer/Eppendorf Xplorer plus – error of measurement

Eppendorf Xplorer/Eppendorf Xplorer plus – single-channel pipettes 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	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

Model	Test tip epT.I.P.S.	Testing volume	Error of measurement			
			Systematic		Random	
			±%	±µL	%	µL
		1000 µL	0.6	6.0	0.2	2
0.125 mL – 2.5 mL red	0.1 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
0.2 mL – 5 mL violet	0.1 mL – 5 mL violet 120 mm	250 µL	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

Eppendorf Xplorer/Eppendorf Xplorer plus – multi-channel pipettes with fixed cone spacing

Model	Test tip epT.I.P.S. epT.I.P.S. 384	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	0.5 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	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
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 L 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

Eppendorf Xplorer/Eppendorf Xplorer plus – multi-channel pipettes with adjustable cone spacing

Model	Test tip epT.I.P.S. epT.I.P.S. 384	Testing volume	Error of measurement			
			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

8.17 Maximum permissible errors according to DIN EN ISO 8655

The maximum permissible errors always refer to the entire system consisting of the pipette and pipette tip. Dispensing volumes less than 10 % of the nominal volume are not taken into account.

8.18 Air-cushion pipettes with fixed and variable volume

- Reference 2
- Eppendorf Research plus
- Eppendorf Xplorer
- Eppendorf Xplorer plus

Single-channel pipette

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 max. 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

Nominal volume	**Testing volume in % of nominal volume**	**DIN EN ISO 8655 max. permissible errors**	
		Systematic	**Random**
		±%	**%**
> 5000 µL - 20000 µL	10	6.0	3.0
	50	1.2	0.60
	100	0.60	0.30

Multi-channel pipette

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 max. 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

8.19 Positive displacement pipettes

- Biomaster
- LiquidPro
- Varipette/Maxipettor

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

8.20 Multi-dispensers

- 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 max. 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

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 max. permissible errors	
		Systematic	Random
		±%	%
	50	2.0	1.2
	100	1.0	0.60
> 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

8.21 Single stroke dispensers

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

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 max. 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

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 max. permissible errors	
		Systematic	Random
		±%	%
	50	1.2	0.40
	100	0.60	0.20

8.22 Mechanical piston-stroke burettes

- Top Buret H
- Top Buret M

Nominal volume	Testing volume in % of nominal volume	DIN EN ISO 8655 max. 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

An adjustment is used to set the dispensing volume so that the systematic error is minimized for the intended application. The dispensing volume is changed by approximately the same volume across the entire volume range. Adjustment may be necessary due to differing calibration results or differing conditions.

The random error is not affected by an adjustment. You can reduce the random error by replacing worn parts. The random error is also influenced by handling.

9.1 Adjustment in case of differing calibration results

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

Unlike mechanical pipettes, an electronic pipette is adjusted over the entire stroke length using a fifth-degree polynomial function. Therefore, as a user, you cannot adjust the manufacturer's adjustment of electronic pipettes yourself. If the measuring results are outside the manufacturer's thresholds, the pipette is defective. Send the defective pipette to an authorized service center.

9.2 Checking for causes of dispensing deviations

1. Ensure that all test requirements have been met:
   - The tip cone is in good condition.
   - The pipette tip is compatible with the pipette.
   - The dispensing system is leak-tight (pipette and pipette tip).
   - The test liquid was aspirated and dispensed 5 times (saturated air cushion).
   - The test liquid, the dispensing device, and the ambient air are at the same temperature.
   - The test liquid complies with the requirements of ISO 3696.
   - The immersion depth during liquid aspiration is observed.
   - The liquid is dispensed onto the vessel inner wall.
   - The pipetting speed is correctly set.
   - The balance resolution is appropriate for the testing volume.
   - The weighing location is free from drafts.
   - The evaluation of the measuring results is error-free.
2. Decide whether adjustment is necessary.
3. Adjust the dispensing device, see product information at www.eppendorf.com/manuals.

You can also send the dispensing device to an authorized service center for adjustment.

9.3 Changing the adjustment to different conditions

The physical properties of liquids and the ambient conditions are key factors affecting piston-stroke pipettes. You can adjust mechanical and electronic pipettes to these conditions.

Changing the adjustment is advisable in the following cases:

- For liquids with significant deviations in their physical properties compared to water (density, viscosity, surface tension, vapor pressure).
- For capillary action when the pipette tip is immersed (e.g., with DMSO).
- For changes in atmospheric pressure due to the altitude of the location.
- For pipette tips that differ significantly in geometry from standard tips (e.g., extended epT.I.P.S.).

1. Adjust the dispensing device, see product information at www.eppendorf.com/manuals.

10 Glossary

Accuracy
The degree of approximation between the average value of a large series of measurement results and a recognized reference value, in accordance with the ISO 3534-1 and DIN ISO 5725-5 standards.

Additional volume
Sum of remaining stroke and reverse stroke.

Air cushion principle
Design characteristic for piston-stroke pipettes. An air cushion separates the liquid in the plastic tip from the piston inside the pipette. The air cushion is moved by the piston and acts like an elastic spring.

Autoclaving
Physical method of sterilization. Thermal process used to kill microorganisms and inactivate viruses and enzymes. This process does not completely destroy the DNA. The objects to be autoclaved are stored in a pressure vessel with water vapor at 121 °C, 1000 hPa (1 bar) positive pressure for 20 min.

Blow out
Movement of the piston to the lower position to blow out remaining liquid from the pipette tip. Liquid from the blow out belongs to the dispensing volume when pipetting. When reverse pipetting, the liquid is **not** part of the dispensing volume.

Bottle-top burette
Piston burettes are used for dispensing liquids until external criteria (e.g. pH, conductivity) have been met. Dispensing device for the dispensing of large amounts of fluid. The maximum dispensing volume corresponds to the contents of the bottle. The Top Buret M and Top Buret H belong to this group.

Bottle-top dispenser
Dispensing device that can dispense liquid once per liquid aspiration. The Varispenser and Varispenser plus belong to this group.

Calibration
Determination of the systematic error of a device based on a referenceable standard. The systematic error must be determined in a reliably reproducible way. Calibrations do not involve any intervention changing the device.

Combitips advanced
Dispenser tip for all Eppendorf Multipettes and Repeaters. Dispenser tips are single-use consumables and comprise a piston and a cylinder and work according to the principle of positive displacement.

Cycle
The upward piston movement (liquid aspiration) and the downward piston movement (liquid dispensing) together form a cycle.

DIN EN ISO 8655series of standards
The series of standards defines requirements for volume measuring instruments with pistons, etc. Thresholds for systematic and random error and the test procedure.

Dispenser
A dispenser is a dispensing device that works according to the principle of positive displacement. There is a multi-dispenser and single stroke dispenser.

Dispensing device
Volume measuring instrument with piston.

Dispensing step
Liquid dispensing of the partial volume set for positive displacement pipettes and electronic pipettes.

Dispensing system
The dispensing device and corresponding dispensing tip comprise the dispensing system.

Dispensing volume
Volume per dispensing step.

epT.I.P.S.
Trade names for pipette tips without filter from Eppendorf SE.

Factory adjustment
Factory adjustment is a permanent change to the dispensing volume of a pipette with adjustable volume. The dispensing volume is changed by approximately the same amount across the entire volume range of the pipette.

If the set volume is outside the permitted thresholds compared to the dispensed volume, the counter and piston stroke are decoupled and readjusted. The changed volume must be checked gravimetrically.

Fixed-volume pipette
The dispensable volume is fixed and cannot be changed.

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

Gravimetric volume testing
Mass determination of a specified volume under lab conditions. The specified volume is calculated from the weight of the fluid quantity using the density value at the measuring temperature.

Increment
The amount or degree by which a quantity gradually increases.

Leak tightness
Impermeability of air or liquid. With dispensing devices, the area between the liquid and the piston must be sealed.

Maximum permissible error
Information relating to the highest or lowest permissible deviation of the volume dispensed from the nominal or useful volume. The systematic and random errors are specified for the maximum permissible errors. The maximum permissible errors are specified once according to DIN EN ISO 8655 and once according to the manufacturer limits for Eppendorf SE.

Maximum volume
The maximum usable volume for the dispensing procedures.

Multi-dispenser
Dispensing device that can dispense liquid multiple times per filling volume. All Multipettes/Repeaters are multi-dispensers. Multi-dispensers are also referred to as manual dispensers.

Nominal volume
The nominal volume of a piston-stroke pipette and burette is imprinted and is the maximum dispensing volume specified by the manufacturer. With mechanical dispensers, the nominal volume comprises the volume of the dispenser tip, together with the highest dial setting. With electronic dispensers, the nominal volume comprises the volume of the dispenser tip, together with the highest volume that can be set.

Piston-stroke pipette
A piston in the pipette is moved up or down, depending on the task. The liquid is collected in a pipette tip.

Positive displacement principle
Design feature for piston stroke dispensers. The liquid remains in direct contact with the piston of the dispenser tip when aspirating and dispensing (Combitips).

Precision
Spread of the measured values around the set value. A small spread corresponds to a high level of precision. A large spread corresponds to a low level of precision.

Random error
Measure for the scattering (standard deviation) of the measured values around the average value.

Remaining stroke
Liquid reserve. The amount of liquid remaining after all dispensing steps have been completed.

Remaining stroke lock
The remaining stroke lock prevents an incorrect volume from being dispensed when actuating the operating lever if there is no longer sufficient liquid available for the dispensing volume.

Stroke
The stroke is the distance traveled by a piston.

Systematic error
Deviation of the average value of the dispensed volumes from the selected volume.

Temporary adjustment
A temporary adjustment is an active, reversible change to the dispensing volume of a pipette. The dispensing volume is changed across the entire volume range of the pipette by approximately the same amount.

A temporary adjustment may be necessary to adapt the pipette to the following conditions:

- Changes in atmospheric pressure at the location
- Non-aqueous solutions with a different density, viscosity, surface tension, or vapor pressure compared to water
- Use of special pipette tips (e.g., long pipette tips with a modified air cushion volume)
- Alternative pipetting technique (reverse pipetting)

Vapor pressure
Designation for the pressure a body (solid or liquid) exerts with its steam in a closed container. The steam exists in an equilibrium with its liquid or solid state. The vapor pressure increases as the temperature rises. Every pure liquid has a vapor pressure of 1013 hPa (mbar) at boiling point. The risk of volume errors due to high vapor pressure can be reduced by pre-wetting the tip.

Vessel
Micro test tube or individual well in a plate.

Viscosity
The viscosity describes the resistance of liquids and suspensions. The dynamic or absolute viscosity is given in Pa·s or mPa·s. In older literature, the unit P or cP is used (1 mPa·s corresponds to 1 cP). At ambient temperature, a 50-% glycerol solution has a viscosity of approx. 6 mPa·s. The viscosity significantly increases with the increasing glycerol concentration. At ambient temperature, pure anhydrous glycerol has a viscosity of approx. 1480 mPa·s.

Wall dispensing
Dispensing of liquid at the tube inner wall. The pipette tip or the dispenser tip is held at the tube inner wall and the liquid is dispensed.

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

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