White Paper

RAININ
Pipetting 360°

Pipette Choice and Maintenance

Best Practice Matters

In many laboratories, the correct use and maintenance of pipettes is essential to ensure precise, accurate results. Researchers have a broad range of pipettes to choose from – fixed or variable volume, air or positive displacement, single channel or multichannel, manual or electronic – and selection of the most appropriate type and volume range is crucial. Equally important is establishing a regular pipette testing program to confirm that performance remains within the specified limits, supported by preventive maintenance and calibration if necessary.

This white paper is an introduction and practical guide to the proper use, testing, maintenance and calibration of piston pipettes for scientists, technicians and other laboratory workers, covering single channel and multichannel, manual and automatic pipettes with dispensing volumes ranging from microliters to milliliters. The different types of pipette and their operating principles are described, including recommendations for selecting the most appropriate pipette according to specific applications. Guidance is provided for routine pipette performance testing, as well as general daily pipette care, maintenance and calibration. Finally, the importance of operator training to ensure compliance with best pipetting practice is discussed.

METTLER TOLEDO

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1 Pipette Types

Pipettes can be divided into two main groups, air displacement and positive displacement (Figure 1), which are further sub-divided into fixed and variable volume pipettes. The operating principle is essentially the same for all types of pipette: a predetermined volume of liquid is forced out of the pipette tip by the application of mechanical pressure to a piston or plunger working over a fixed length in a cylinder. The volume of liquid dispensed is determined by the diameter of the piston and the length of the piston stroke.

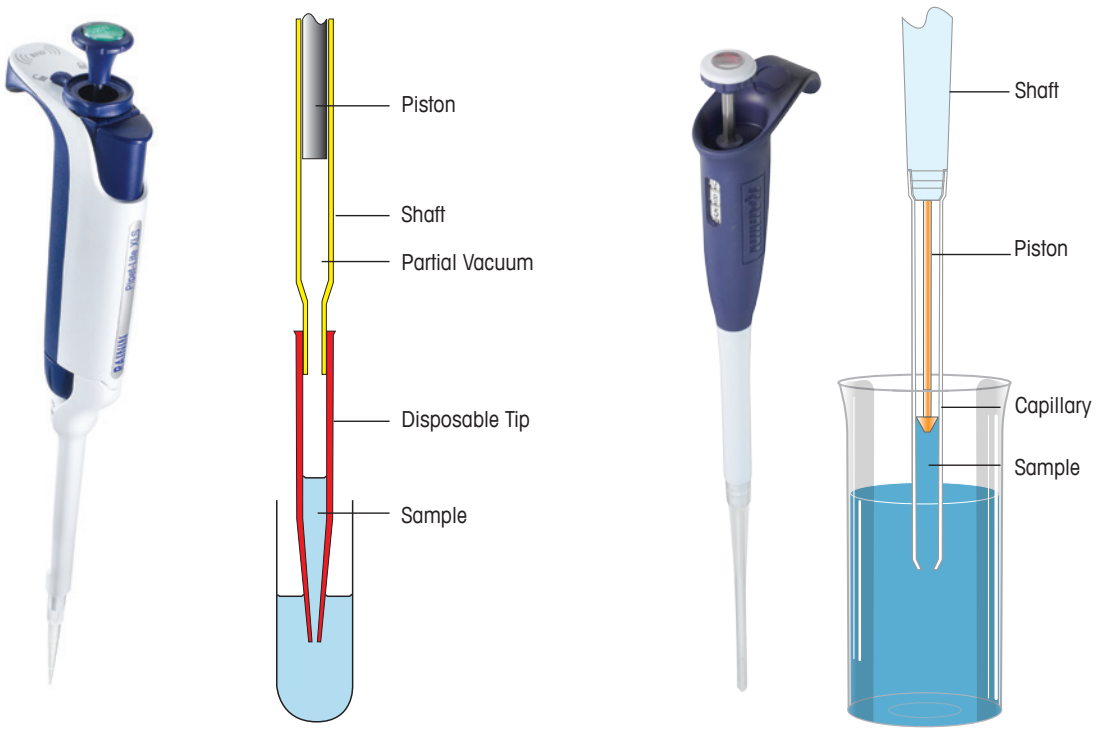


Figure 1: Air and positive displacement pipettes

1.1 Air Displacement Pipettes

Air displacement pipettes offer economical, accurate, and precise pipetting of aqueous solutions and are the most common type of laboratory pipette. The pipettes operate by depressing the plunger button down to the first stop and placing the end of the tip into the liquid sample. When the plunger is released, the attached piston is returned to its original position by the piston spring – or by the motor in an electronic pipette – generating a partial vacuum and creating a void as it moves up within the pipette body. Atmospheric pressure forces liquid into the pipette tip, completely filling this void (Figure 2). In principle, the volume of liquid in the tip is the same as the volume of air that was displaced from the cylinder by the piston.

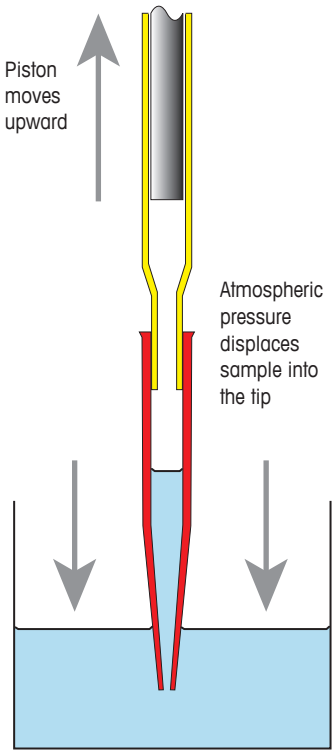


Figure 2: Air displacement pipette operation.

1.2 Positive Displacement Pipettes

Although not as common as air displacement pipettes, positive displacement pipettes are frequently used in the laboratory as they offer precise pipetting of liquids that are viscous, dense, volatile or corrosive. Positive displacement pipettes use a disposable piston and capillary system to create a void of the selected volume. The piston comes in direct contact with the sample and, as it moves upward, draws the sample into the capillary. Because a new piston is used for each sample, these pipettes prevent cross-contamination of the pipette by the sample, making them ideal for PCR and other critical applications.

1.3 Fixed Volume Pipettes

Fixed volume pipettes are designed to dispense a specific, set volume of liquid – the nominal volume – which cannot normally be altered. However, some fixed volume pipettes are designed to allow minor adjustments to be made within set narrow limits, enabling users to compensate for errors found during performance testing or when using liquids with unique physical properties.

1.4 Variable Volume Pipettes

Adjustable volume pipettes have been available since the early 1970s and allow the user to vary the dispensing volume over a range specified by the manufacturer. For these pipettes, the nominal volume is defined as the upper limit of the pipette's volume range.

1.5 Variable Volume Pipettes

Manual single channel pipettes with variable volume settings ranging from 2 µL to 20 mL are by far the most commonly found laboratory pipettes. Pipette design has advanced considerably over time to incorporate features such as a large ergonomic plunger button for aspirating and dispensing liquid, single-handed volume adjustment, a mechanical volume display, a finger-hook to allow the hand to rest between pipetting cycles and an ejector button with a shock absorber for easy tip ejection (Figure 3).

Figure 3: A manual single channel pipette.

1.6 Electronic Single Channel Pipettes

Electronic pipettes have been available since the mid-1980s and use microprocessor-controlled aspiration and dispensing initiated by an electronic trigger rather than a plunger button. Most users will achieve more consis tent sample pick-up and dispensing with an easy-to-operate electronic pipette incorporating a good user interface and large color screen, improving accuracy and repeatability and virtually eliminating user-to-user variability. (Figure 4)

Electronic pipettes are versatile, enabling intricate tasks such as repeat dispensing, controlled titrations, serial dilutions and measuring unknown sample volumes, plus a range of other programmable functions. Repeat movement of the piston to mix two solutions in the tip is easily programmed, and controlled aspiration and dispense speed allows a wide variety of liquids to be accommodated (fast speeds are ideal for pipetting aqueous samples, slower speeds are more suited to viscous, foaming or shear-sensitive samples.)

Figure 4: An electronic single channel pipette.

1.7 Multichannel Pipettes

Lightweight, ergonomically-designed multichannel pipettes (Figure 5) with rapid, secure tip loading and consistent sample pick-up across all channels are ideal for high throughput applications such as 96-well plate ELISAs and PCR for DNA synthesis. Standard multichannel pipettes are available in both manual and electronic formats, covering a wide range of dispensing volumes, and adjustable spacer models, allowing tip spacing to be set up to accommodate 24- or 96-well plates, as well as tube racks.

Figure 5: Manual and electronic multichannel pipettes.

2 Pipette Performance Management

2.1 Best Practices for Pipette Quality Control

As precision laboratory instruments, pipettes are subject to stringent quality control regulations. Noncompliance can cause major headaches for metrology and the end user, and correcting the problem is often costly and labor intensive.

Pipette failures have many consequences, ranging from erroneous experimental results to products manufactured with faulty pipettes being recalled. Not only is this costly and time consuming, but there is a risk of failing to publish or get to market in time, losing market share and a loss of credibility. The effectiveness of a regulated laboratory's GMP/GLP program becomes questionable, making more intensive audits likely, and validation costs increase. The more frequently pipettes are serviced, the sooner defective pipettes will be detected and taken out of service, decreasing the risk of incorrect results and helping to minimize the need for corrective action.

High quality pipettes, professionally serviced and maintained, are crucial to scientific success and compliance with regulatory requirements. Pipetting performance is influenced by many factors, most notably regular routine testing and maintenance, and correct pipetting technique. As precision instruments, pipettes are subject to the same quality regulations – for example GLP and GMP – regarding calibration and maintenance as other laboratory instruments to ensure that the desired performance specifications are met. This means that pipettes must:
have regular functional checks to verify performance and be periodically calibrated according to a documented procedure
undergo periodic maintenance and be properly handled
be operated by trained individuals with demonstrated competence

This ensures consistent performance, which helps reduce the risk of faulty conclusions based on incorrect data.

2.2 Sources of Liquid Delivery Variability

Pipetting variability has many different causes, most commonly:

- Systematic failures – foreseeable failures due to predictable wear, based on factors such as frequency of use and maintenance intervals.
- Random failures – unexpected failures due to arbitrary events such as accidents or mishandling. These failures occur randomly with respect to the pipette service cycle and cannot be accurately predicted.
- Operator technique – inconsistent or incorrect pipetting technique is probably the largest single source of liquid delivery variability, and is frequently due to lack of training in the correct use of pipettes.
- Environmental factors – pipette performance varies under different environmental conditions, for example, changes in temperature and humidity.
- Device tolerance limits – inaccuracy and imprecision inherent in the pipette itself can also give rise to a small amount of variability in liquid delivery. Typically, these limitations are specified by the manufacturer, based on best-case performance.

2.2.1 Systematic Versus Random Failures

Systematic pipette failures are those that arise from simple wear, generally reflecting the extent to which a pipette is used and its frequency of maintenance. Adjusting the service and calibration interval, based on a review of the "as found" performance history of the pipette, may help prevent these failures. In contrast, random failures are due to accidents, mishandling or other unplanned events, and can occur at any point in the service cycle. Owing to their unpredictable nature, they are harder to eliminate. For example, an operator may inadvertently draw liquid into the pipette body, causing the piston to corrode, or simply drop the pipette. Such failures cannot be prevented by scheduled maintenance cycles, but regular pipette performance testing will help detect them earlier.

3 Pipette Performance Assurance

Assuring pipette performance means establishing a dedicated care and maintenance plan to ensure pipettes are regularly cleaned and decontaminated, and confirming that performance evaluation, calibration and preventive maintenance is carried out. While some of these tasks can be performed by the pipette user, others require the use of a specialized service provider (Table 1).

Task	Description	Responsibility
Cleaning and decontamination	External cleaning and decontamination of the pipette at regular intervals	Pipette user (day to day) / Service provider (with PM service)
Inspection	Inspection of the pipette to check for any damage that may have occurred	Pipette user (day to day) / Service provider (with PM service)
Performance testing	Pipette performance check, scheduled based on process risk (daily or at least weekly)	Pipette user
Calibration	Pipettes show to be calibrated according to application requirements. Calibration intervals are typically set according to quality standards and requirements.	Service provider / ISO 17025 accredited laboratory
Preventive maintenance	Pipette functionality check, including replacement of worn parts, done at least once per year or more often for high usage or when pipetting potentially ruinous liquids.	Service provider / ISO 17025 accredited laboratory

Table 1: The essential requirements of a pipette care and maintenance plan.

3.1 Multichannel Pipettes

3.1.1 Cleaning Decontamination

Choose solvents for cleaning and decontamination, they will remove the liquids that the pipette has had contact with, follow the manufacturer's recommended cleaning protocol carefully since some solvents can adversely affect the pipette. With electronic pipettes, take extra care to ensure that cleaning fluids do not come into contact with the electronic controls. Many pipettes can be autoclaved, although partial dismantling may be necessary, follow the manufacturer's instructions regarding the suitability of the sterilization media used and the maximum temperatures and pressures allowed.

3.1.2 Inspection

Pipettes should be inspected at regular intervals to ensure proper functioning and to check for wear or damage that could affect accuracy and precision. It is essential to check for smooth plunger movement and for signs of tip leakage, the latter could indicate failed sealing components or an ill-fitting pipette tip. Because accuracy is dependent on achieving a good seal between the tip and the pipette shaft, carefully inspect the end of the shaft for any marks or distortion. Note that some fluids, such as high vapor pressure liquids, can cause leaks as a small amount of the liquid changes to a gaseous state, increasing in pressure in the dead volume of air between the piston and the liquid in the pipette.

4 Testing, Calibration and Preventive Maintenance

To assure reliable pipette performance, a program of regulatory scheduled testing and maintenance should be established and include these best practices:

- verifying pipette performance, at a frequency based on the mean time between failures (MTBF), to ensure data validity
- immediately verifying the performance of any pipette that has been dropped, mishandled, or which is associated with questionable data
- planned comprehensive preventive maintenance with thorough cleaning, seal/O-ring, shaft, piston replacement when needed, and re-greasing per manufacturer specifications
- pipette calibration with appropriate balances: such as micro and analytical balances for small volume pipettes and special balance for multichannel pipette calibration
- train operators in the correct operation and storage of pipettes, with periodic verification of pipetting competence under everyday working conditions

The frequency of pipette performance testing, preventive maintenance and calibration varries significantly between laboratories. In quality control, diagnostic and other laboratories that routinely audit equipment to comply with stringent regulatory guidelines, pipette servicing is performed far more frequently than, for example, in academic research departments. In general, the frequency depends largely on the significance of a pipette failure, as illustrated in Figure 6.

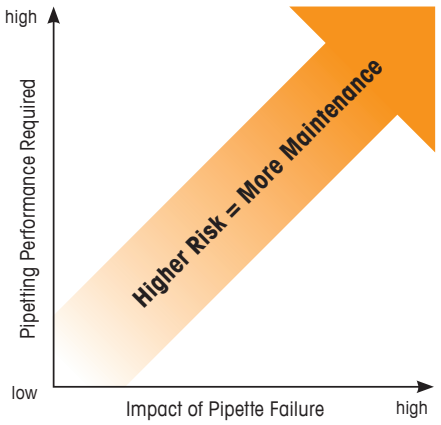


Figure 6: A risk-based approach to pipette maintenance.

The relationship is simple; if your application includes rare samples and/or costly procedures or reagents, or the accuracy of the results is critical, then your pipettes should be checked and serviced more frequently.

4.1 Testing and Calibration

Although the methods used overlap to a considerable extent, a distinction must be made between testing and calibration. Testing against process tolerances is a routine operation, normally performed by the user to ensure that pipette performance is within pre-established acceptable limits. Calibration must be performed by a specialized service provider and compares the expected volume with the actual volume delivered by a pipette together with the associated measurement uncertainty.

4.1.1 Pipette Performance Testing

Routine pipette performance checks (often called Pipette Check or Quick Check) are essential to ensure correct functioning, accuracy, and to maintain data integrity. To identify any maintenance and (re)calibration needs, performance should be compared against the manufacturer's specifications or ISO 8655-1:2002 and process requirements on a regular basis.

For piston pipettes, ISO 8655-1:2002, 7.3, recommends establishing a regular testing routine using either ISO 8655-6 or alternative test methods that take into account:

- the required accuracy of liquid delivery
- the frequency of use
- the number of operators using the pipette
- the number of dispense cycles performed on each occasion of use
- the nature of the liquid dispensed (corrosiveness, solvent strength, etc.)
- supplier recommendations

Pipette accuracy is normally determined gravimetrically. A performance check to verify the entire pipetting system – user, pipette, tip and environment – requires a calibrated laboratory balance, a thermometer, deionized and degassed water, and a suitable weighing vessel (Figure 7). An evaporation trap is also recommended. Software packages and balances are available to guide the process, analyze data and record pipette performance. Pure water is dispensed in a single pipetting operation, weighed, and the mass recorded. The mean value of the weighing series is multiplied by the "Z-factor"[1] to convert the mean value of the mass to a volume result.

Replicate measurements are made and corrections applied to compensate for any variation from standard temperature and atmospheric conditions, as well as any significant evaporation of the water during the test period. Variable volume pipettes should be tested at two or three volume settings: at the nominal volume (100%), 50% of the nominal volume and at the lower limit of their range (as specified by the manufacturer) or 10% (of the nominal volume) as described by ISO 8655 as the useful minimum volume (ISO 8655-1:2002, section 3.1.7, Note 1). The results are compared to the appropriate specifications to determine the accuracy and precision of the pipette. In order to be considered within specification, results must fall within an accuracy range, and not exceed a precision value.

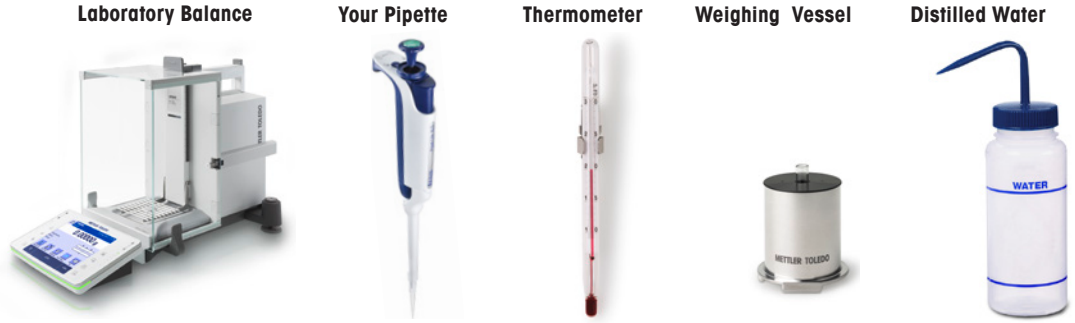


Figure 7: A quick check requires minimal equipment.

Taken in account the different circumstances, usage and risks, a pipette performance test of accuracy and an estimation of precision is recommended as follows:

- A monthly check at 100% and 10% volume with 4 repetitive measurements at low usage, having no strict SOP or guidelines, low valuable samples
- A weekly check at 100% and 10% volume with 4 repetitive measurements at normal usage, having SOP guidelines, using valuable samples or with critical consequences
- A daily check at 100% and 10% volume with 4 repetitive measurements at intensive usage, having strict regulatory guidelines, using expensive sample, small result differences have a high impact.

It is important to use an analytical balance with a resolution appropriate to the selected volume of the pipette (Table 2) and sample size must also be considered (for a performance check four replicate measurements are sufficient).

Pipette Dispensing Volume	Resolution (mg)	Repeatability and Linearity (mg) [1]	Standard Uncertainty Measurement (mg)
1 µL – 10 µL	0.001	0.002	0.002
10 µL – 100 µL	0.01	0.02	0.02
100 µL – 1,000 µL	0.1	0.2	0.2
1 mL – 10 mL	0.1	0.2	0.2
10 mL – 200 mL	1	2	2

(1) If the standard uncertainty measurement of a balance is known (e.g. from the balance calibration certificate), it may be used instead of repeatability and linearity. The standard uncertainty measurement should not be more than three times the resolution.

Table 2: Minimum balance requirements for pipette performance testing (ISO8655-2:2002)

Any balance that meets the conditions above can be used to test pipette performance.

Performance tests (quick checks) generally follow these 10 steps.

1. With a prepared vessel on a tared balance, adjust the pipette to 100 percent of its nominal volume and load the manufacturer's recommended tip.
2. Pre-rinse the tip by aspirating and dispensing the set volume of deionized water three times.
3. Holding the pipette vertically, immerse the tip to the appropriate depth and aspirate the deionized water.
4. Carefully move the pipette over the vessel on the balance and dispense the water. Slide the tip up the side wall to remove any excess liquid.
5. To avoid the effects of evaporation, as soon as the balance stabilizes, record the mass of the water in milligrams.
6. Repeat the process 3 more times using the same tip, recording the mass each time.
7. Eject the tip after the final dispense.
8. Adjust the pipette down to 50 percent of its nominal volume. Pre-rinse a new tip three times, and repeat steps 3-7.
9. With the collected data, calculate the pipette's mean volume, accuracy (mean error) and precision (standard deviation).
10. Compare results vs. manufacturer's specs. If the results do not match, the pipette might require servicing, or the operator may require further training in technique. Calculation sheets and more information are available at: www.mt.com/rainin-quickcheck.

1 The Z-factor is used to convert mass into volume according to temperature and pressure. The Z-factor is specified in Annex A of the EN ISO 8655-6:2002 standard.

4.1.2 Automating Performance Tests

As devices become "smarter" and more interconnected, procedures like performance checks are becoming more automated. Here's an example of how METTLER TOLEDO is interlinking equipment across its various product lines in order to simplify basic lab processes:

Labs with Rainin XLS and XLS+ pipettes and METTLER TOLEDO XPE or XSE balance can use an application onboard the balance to guide them through the performance check and perform all of the calculations. This integrated solution uses a Rainin SmartStand, METTLER TOLEDO EasyDirect Pipette Asset Management software and an XPE or XSE balance equipped with the optional EasyScan Flex RFID reader.

1. A lab manager uses EasyDirect to set up their performance check method.
2. EasyDirect connects wirelessly with SmartStand to record the method directly to the pipette.
3. SmartStand alerts users when a performance check is due.
4. For the performance check, the EasyScan reader on the XPE or XSE balance reads the assigned method on the pipette's RFID chip, then guides the user through each step of the method and performs all calculations.
5. If the pipette passes, the balance writes the next quick check date onto the RFID chip and prints a certificate, showing the method used, measurements, and pass/fail results.

4.2 Preventive Maintenance and Calibration

Preventive maintenance and calibration have equally important roles to play, and both are included in a pipette service cycle (Figure 8). Typically, preventive maintenance can eliminate 97% of errors, while 3% of errors are corrected with calibration services.

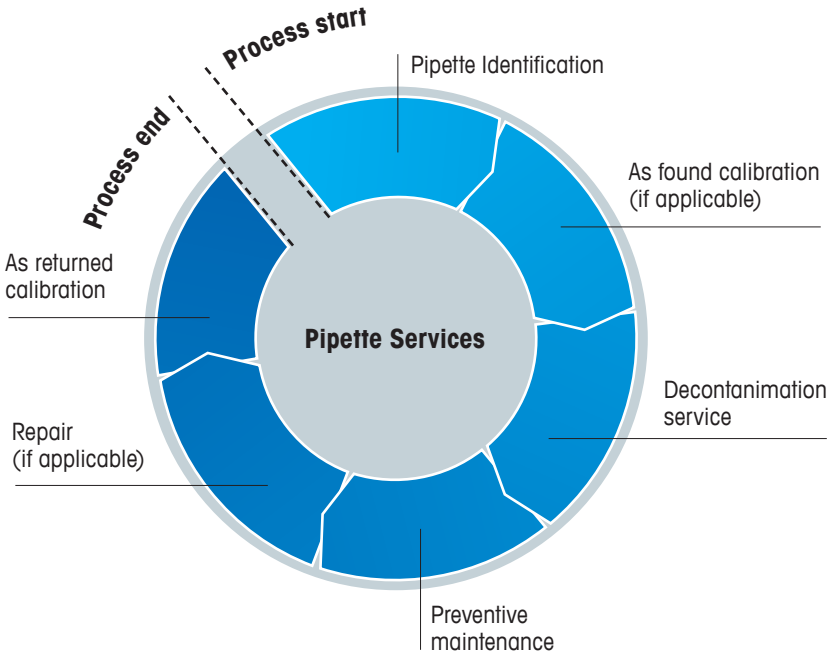


Figure 8: A typical pipette service cycle.

Preventive maintenance is performed at least annually and focuses on long-term performance (Table 3). While this may be carried out on-site by trained laboratory personnel who check pipette function, perform leak tests and replace any parts necessary, the use of a specialized service provider is highly recommended. In contrast, calibration establishes current performance gravimetrically (Table 3) and is always performed in a controlled environment by certified calibration personnel. The pipette's "as found" and "as returned" status is determined and a certificate of calibration stating the accuracy and precision of the pipetting results is issued.

	Preventive Maintenance	Calibration
Primary objective	Ensures long-term pipette performance	Checks current pipette performance
Service(s) performed	Parts replacement Function check Leak test Cleaning	Gravimetric measurements - As found - As returned Calibration certificate
Environment	Professional lab or on-site	Controlled lab environment
Staff, equipment & system requirement	Access to manufacturer parts Highly trained personnel Inventory control process	High precision micro balances Certified calibration personnel Calibration software
Recommended Frequency	Minimum once per year	As mandated by quality requirements

Table 3: The differences between calibration and preventive maintenance.

4.2.1 Preventive Maintenance

Preventive maintenance is the key to maintaining peak pipetting performance and reducing, if not preventing, out-of-tolerance measurements between calibrations. Over time, piston surfaces can deteriorate and become rough, causing premature seal failure, inaccuracy or sample contamination, and shaft ends can become worn, especially if force is applied when mounting tips. Leaks can gradually develop and, if not discovered early, adversely affect data integrity.

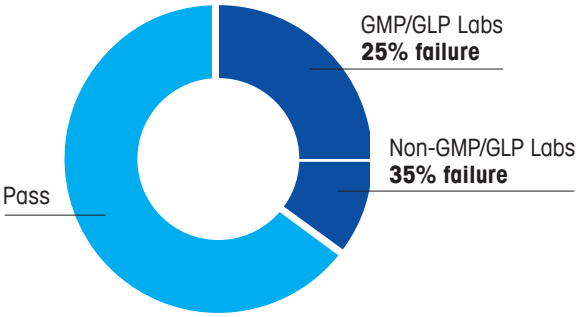
As part of a comprehensive preventive maintenance, function and leak tests are performed and, where necessary, repairs are made and parts are replaced, ideally with original manufacturer spares (Table 4).

Preventive maintenance	Repair
Inspection and function check	Mechanical failures – plunger, micrometer, tip ejector, etc.
Cleaning	Electronic failures – PCBs, LCD screens, etc.
Pressurized leak test	
Replacement of parts such as seals, O-rings, shafts and pistons, ideally with original manufacturer spares	

Table 4: Experienced service providers offer comprehensive preventive maintenance and repair of pipettes.

It is essential that pipette performance is "as new" after servicing, ensuring peak performance and trouble-free pipetting. An internal study of pharma customers on the East Coast (U.S.) between 1998 and 2003 found that pipettes that were 1) not serviced or 2) subject to calibration and repairs alone had 'as found' failure rates between 25 and 35% (Figure 9). With regular servicing by a certified provider using manufacturer approved spare parts, as found failure rates decreased to below 5% (Figure 10), clearly demonstrating the benefit of professional preventive maintenance. For example, experienced service providers recommend that under normal use, pipette seals should be replaced at least once per year, and shafts and pistons every three to five years. A recent internal study that analyzed data from over 120,000 pipettes serviced in a year indicated that an estimated 95% of all pipette failures can be attributed to one or more components of the sealing system (Figure 11).

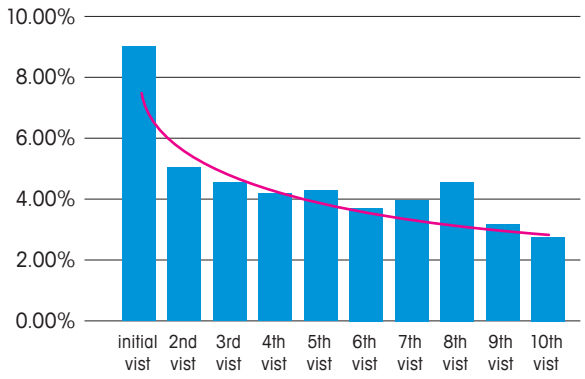
Pipette failure rates without preventive maintenance



Based on East Coast Pharma study – 1998-2003

Figure 9: Pipette failure rates tend to be between 25 and 35% without preventive maintenance.

Pipette as found failure rate when continuously serviced by Rainin



Based on Rainin service center 2011 data

Figure 10: The benefit of regular pipette servicing.

Sealing System Failures

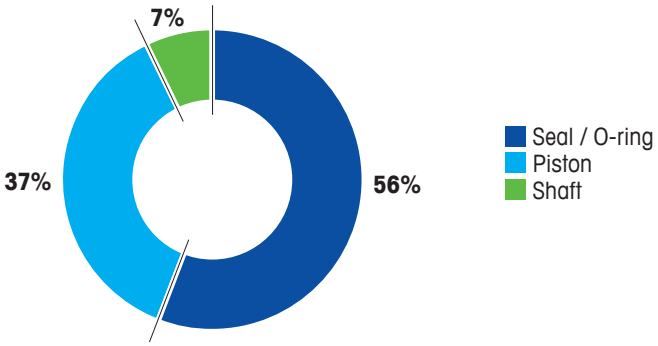


Figure 11: Reported causes of pipette failure.

4.2.2 Calibration

Calibration is defined as testing of the pipette against the manufacturer's specification by a certified service provider, calculating the measurement uncertainty of the result. However, calibration is frequently confused with other procedures, including performance checks using a laboratory balance, adjusting the calibration mechanism to comply with a given set of specifications, or a wide range of compliance and regulatory activities which, performed properly, help ensure trouble-free regulatory audits. A comprehensive pipette service provides:

- "as found" performance data
- preventive maintenance
- "as returned" performance data
- calibration certificate
- service label

4.2.2.1 Professional Calibration Set-up

Professional calibration service providers should be ISO 17025 accredited and can meet or exceed ISO 8655 guidelines. Calibration service performed according to ISO 17025 is carried out in a controlled environment, using marble weighing tables in a room with carefully regulated temperature and humidity, free from vibration and drafts. Professional calibration service facilities provide:

- Skilled, qualified staff to perform calibration in a controlled environment – a vibration and draft-free room on the ground level with carefully controlled relative humidity, atmospheric pressure and temperature
- Appropriate gravimetric balances (Table 2) that are regularly calibrated using weights traceable to global standards, placed on 600 pound (~ 300kg) marble tables away from walkways and windows
- Pipettes are calibrated per the manufacturer published specifications at appropriate volume settings (typically 10%, 50% and 100%)
- Pipettes and the deionized water are allowed to equilibrate to room temperature prior to calibration
- To minimize errors due to evaporation, the test cycle time is kept to a minimum. For very small volumes, mathematical compensation for evaporation is applied

4.2.2.1 Professional Calibration Set-up

The general procedure is based on the gravimetric method described in section 4.1.1 Pipette Performance Testing. Values are adjusted to compensate for evaporation and used to calculate the true mass and volume dispensed, based on the density of water at specific temperatures and corrections for air buoyancy (see ISO 4787). It is important to note that, in contrast to performance testing, which follows process tolerances calibration includes comparison of the pipette performance with the manufacturer's specifications, as well as calculation of the measurement uncertainty.

For fixed volume pipettes, the test volume is the nominal volume. Variable volume pipettes are tested at:

- the nominal volume (100%)
- 50% of the nominal volume
- the lower limit of the volume range as defined by the manufacturer, or 10% as described by ISO 8655 as the useful minimum volume (ISO 8655-1:2002, section 3.1.7, Note 1)

5 Finding a Good Service Provider

Most laboratories have a wide choice of preventive maintenance and calibration service offerings from many providers. Careful consideration is necessary to find the right service provider and should include:

- Are they ISO/IEC 17025 accredited?
- Are genuine manufacturer's spare parts used, and are parts and labor backed by a service warranty?
- Is calibration carried out at least at the 10% and 100% of nominal pipette volume?
- Do they use 6- or 7-digit balances for small volume pipettes and multichannel pipette calibration workstations for multichannel pipettes?
- Are the reported "as found" failure rates[2] greater than 0%?
- Is past report history available and are customer audits encouraged?
- Is the service subcontracted and does it have the flexibility to meet your needs?
- Are there any hidden charges?
- Are pipette technicians certified and subject to periodic proficiency testing?
- Are the calibration certificates generated via a pipette calibration software?
- Is your calibration data backed up on a secured server?

Choosing a service provider that can answer yes to all of the questions above will assure pipette accuracy and precision and give you greater confidence in your experimental results.

2 "As found" status refers to pre-service calibration to establish how a pipette has performed since its last service and calibration. While these should, ideally, be very low, 0% failure rates are questionable since it is unlikely that there would be no failures at all. Pipette as found failures are most commonly due to poor treatment, inappropriate use and lack of day-to-day maintenance by users.

6 Managing the Full Service Cycle

An effective control system needs to be in place to manage a preventative maintenance and service program. Choice of system depends on lab size and regulation requirements.

Full-fledged asset management systems often have extensive databases attached for calibration certificates and methods. They may contain well-developed user-group management solutions. They are also typically expensive and probably be overkill for labs that simply want manage their pipette inventory.

Many labs use Microsoft Excel to track pipette usage and compliance. Updating Excel files requires close attention, and the repetitive, manual nature of the task increases the likehood of data errors.

Labs looking for a way to automate pipette tracking and testing should consider METTLER TOLEDO's EasyDirect Pipette Asset Management software, which includes an integrated Performance Test Database. EasyDirect utilizes SmartStand, a pipette stand with built-in RFID data transfer. SmartStand tracks usage automatically as pipettes go on and off the stand, and it also clearly displays pipette service and calibration status to users at the bench. This keeps lab managers and the entire lab team equally informed and helps flag the need for preventive maintenance early.

7 Operator Training

ISO 8655 states that the total pipetting system consists of three parts:
- pipette
- pipette tip
- operator

The standard recognizes that the source of greatest variability is the operator, and therefore expressly prescribes how to pipette test volumes into a weighing vessel to test performance.

It is important for an operator to understand sources of potential risks for error:
- optimizing the volume range
- correctly setting the volume
- the effect of tip immersion angle, depth and time
- aspiration rate
- dispensing technique
- pre-rinsing pipette tips
- hand-warming effects
- the correct pipette technology for challenging liquids

The table below shows the most commonly made errors, the error effect they have on the final result and how to correct for them.

Observed Effect	% Error	Correction
Dripping tip or maximum permitted errors are exceeded	Up to 50%	Use original or recommended pipette tips for proper seal
Uneven tips on multichannel pipettes	Up to 10%	Use recommended pipette tips
Maximum permitted errors are exceeded due to re-use of tips	Up to 4%	Do not re-use pipette tips
Maximum permitted errors are exceeded due to residual fluid on tip	Up to 3%	Touch off the pipette tip on the vessel wall (wiping distance 8 mm to 10 mm), observing ISO 8655-6
Maximum permitted errors are exceeded due to fluid sticking to the tip	Up to 2%	Pre-wet pipette tip
Maximum permitted errors are exceeded due to hasty techniques	Up to 1.5%	Smooth, rhythmic pipetting technique
Tip depth too deep or at any acute angle	Up to 1%	Hold pipette vertically and observe ISO 8655-6

The best way to avoid the inherent risk of operator errors is to provide regular trainings and regular quick checks of the operator. An operator test runs along the same lines as described in section 4.1.1, but requires a calibrated pipette that is within specifications and that is known to deliver accurate results when used properly. The operator would then have to pipette specified amounts of liquid onto the vessel, record the values. A certain deviation from the target value is to be expected, but values over a certain threshold indicate the operator is in need of training.

For more information on how to pipette correctly, visit www.mt.com/gpp-tips

8 Summary

The correct use and maintenance of pipettes is essential to achieve precise, accurate results. Selection of the most appropriate pipette for the task in hand is crucial, as is the implementation of a regular testing program, supported by preventive maintenance and calibration, and operator training. By following these guidelines, laboratories will achieve maximum accuracy and reproducibility of pipetting.

9 References

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Notes

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