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Application Note

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The Role of Pipette Tips in Achieving the Best Pipetting Performance

Introduction

Today's laboratory consumables business is largely driven by price, and pipette tips are no exception. A laboratory might invest in high quality pipettes, carefully evaluating them against several criteria, such as pipetting performance, ergonomics, ease of use, and the fluency of cleaning and maintenance procedures. Assessment may include a one- to two-week testing period, during which users test the pipettes in their own workflows before making the purchase decision.

Despite all the care and attention given to pipette selection, pipette tips are often selected purely on price and against written specifications. Testing may include confirmation that the tip does not fall off the pipette or cause leakage. Tips are not typically evaluated for their influence on pipetting performance.

This article reports the results of pipette performance testing using different pipette tips, including tips from pipette manufacturers and those from so-called universal tip manufacturers. The results show that careful attention should be paid when selecting tips in order to ensure high quality pipetting results—all tips do not perform equally.

Executive Summary

- Pipette performance specifications always only apply to a system formed by the pipette and its related tip.
- When using pipette tips not supplied by the pipette manufacturer, the supplier's declaration or the certificate of conformity does not apply.
- The data in this article shows that the best pipetting results can be obtained when using a system with a well optimized tip fit.
- The variance in pipetting performance shows that mere physical compatibility is not an indication for high quality pipetting results.

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The Aim of the Study

The goal of this study was to compare the pipetting performance (systematic and random error), of both mechanical and electronic pipettes, using different pipette tips. The aim was to confirm that pipette and tip act as a system, and that pipette tip selection is critical for high pipetting performance.

ISO 8655:2002

The ISO 8655:2002 standard for piston-operated volumetric apparatuses states that tips for piston-operated air displacement pipettes should be fitted in accordance with the pipette supplier's instructions. This is to ensure a good seal is formed between the tip and the tip cone of the piston pipette.

According to the ISO standard, the maximum permissible errors always apply to the total system of piston pipette and tip. The standard points out that when using pipette tips that have not been supplied by the pipette supplier, the supplier's declaration or the certificate of conformity does not apply. The standard recommends using pipette and tips from the same supplier.

ISO 8655:2002 lists possible sources of error for piston pipettes with air interface. The biggest errors listed originate from tips:

- 0.5%–50% error from leaking or poorly fitting pipette tips
- Up to 10% error from tip straightness
- Up to 4% error from re-use of tips

According to ISO 8655:2002, only a leaking piston-cylinder system might produce errors of the same or greater magnitude (up to 50%) as the ones caused by tip issues. All user-induced pipetting errors are estimated to be in the magnitude of 0.5–3%. This also highlights the fact that the pipette tip has an essential role in producing the expected high quality pipetting results.

Tested Pipettes and Tips

Pipette performance testing was performed using Sartorius Tacta® mechanical pipettes with 0.5–10 µL and 100–1,000 µL volumes, and with 0.5–10 µL volume Picus® Nxt electronic pipettes. Three pipettes of each type were used in the tests. All pipettes were new and had recently been factory calibrated at Sartorius according to the gravimetric performance test method described in the ISO 8655-6:2002 standard. The liquid used was water for analytical laboratory use according to ISO 3696, grade 3. Evaporation was minimized with evaporation traps, the measuring room environment was separately controlled, and the actual values were used in calculations. The conversion from mass to volume was done using the correction factor Z given in Table A.1 in ISO 8655-6:2002.

In total, six pipette tips from different manufacturers, packed in single tray racks, were selected for testing with the 10 µL pipettes, and ten tips for the tests with the 1,000 µL pipettes. Pipette tips were sourced both from pipette suppliers and from so-called universal tip manufacturers. One tip was eliminated from further testing after the compatibility test due to its poor fit on the 10 µL pipettes.

Test Method

The mechanical compatibility of the pipette and tip combination was tested before evaluating the pipetting performance. Tips fulfilling the following criteria were accepted for performance testing:

- Can be easily picked with the pipette from tip tray racks
- Attaches easily to the pipette and doesn't fall off
- Doesn't leak, defined in this study as a dribbling of droplets from the tip end within a 20 second test interval
- Can be ejected using the mechanical or electronic tip ejector function. (Note that tips can be mechanically compatible even if the tip ejector doesn't work, although there were no such cases in this study.)

The mechanical compatibility test does not guarantee accuracy or precision. Pipetting performance (random and systematic error) was tested at 100% and 10% of each pipette's nominal volume. Each pipette and tip combination was tested 10 times for each tested volume.

The pipettes were not calibrated for any of the tips during testing.

Results and Discussion

The results of the pipette and tip performance tests can be seen in Figures 1–6. Figures 1 and 2 show the results of testing with the 10 µL Tacta® mechanical pipette at 100% and 10% of nominal volumes. Figures 3 and 4 present the test results of the 10 µL Picus® Nxt electronic pipette. Figures 5 and 6 show the results of testing with the 1,000 µL Tacta® mechanical pipette.

The results indicate that there are greater differences in how the pipette and tip systems perform with smaller volumes of liquid, both when comparing the performance of 10% volume against 100% nominal volume and when comparing the performance of 10 µL pipettes against 1,000 µL pipettes. This is due to greater sensitivity at smaller volumes to all kinds of small variations, such as manufacturing defects and tip fitting issues.

Electronic pipettes produce up to 50% less random error than mechanical pipettes. This is due to reduced operator-induced error—a well-known benefit of electronic pipettes that eliminates the need for precise thumb control during pipetting.

When comparing the performance of pipette and tip systems, the results show that the selection of pipette tip makes a great difference to pipetting performance. This can be explained by multiple factors. First, air displacement pipettes are typically designed for an air column of a certain volume and the corresponding hydrostatic pressure. Changing tip dimensions change these two fundamental measures, typically lowering performance. Second, the sealing surface area between tip and tip cone is optimized for the tip designed by the pipette manufacturer. For some universal

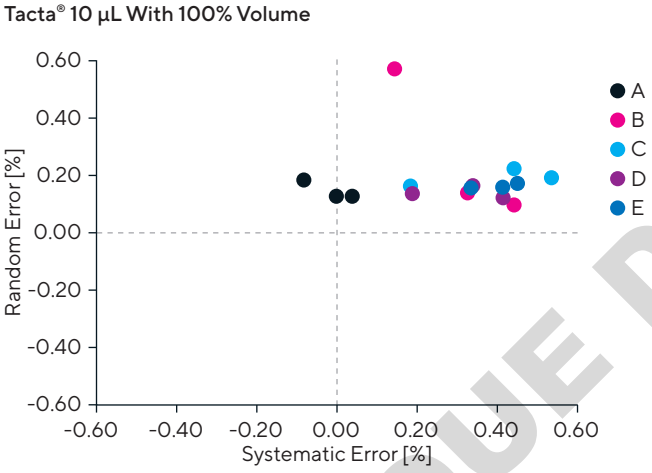

Figure 1: Results of testing using 10 µL Tacta® at 100% of nominal volume

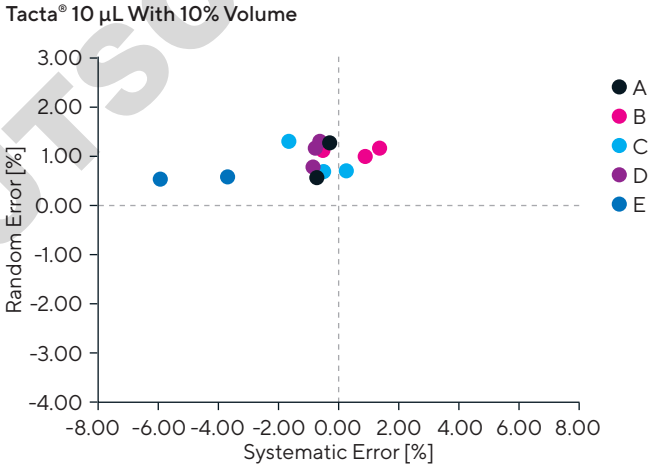

Figure 2: Results of testing using 10 µL Tacta® at 10% of nominal volume

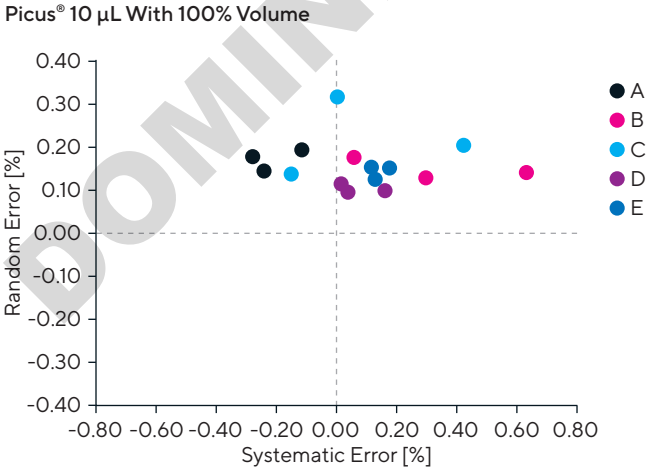

Figure 3: Results of testing using 10 µL Picus® at 100% of nominal volume

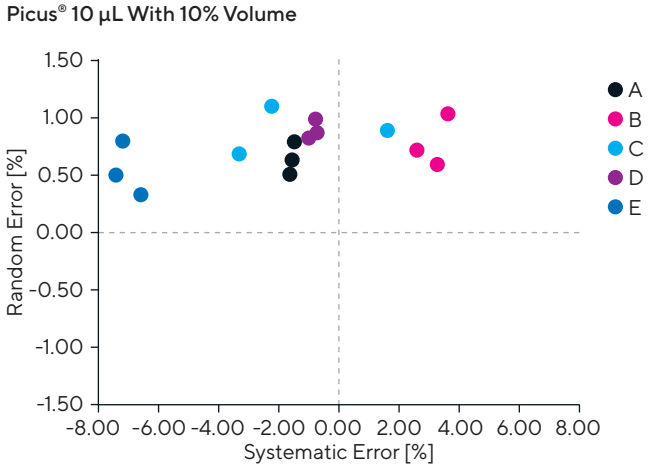

Figure 4: Results of testing using 10 µL Picus® at 10% of nominal volume

Tacta® 1000 µL With 100% Volume

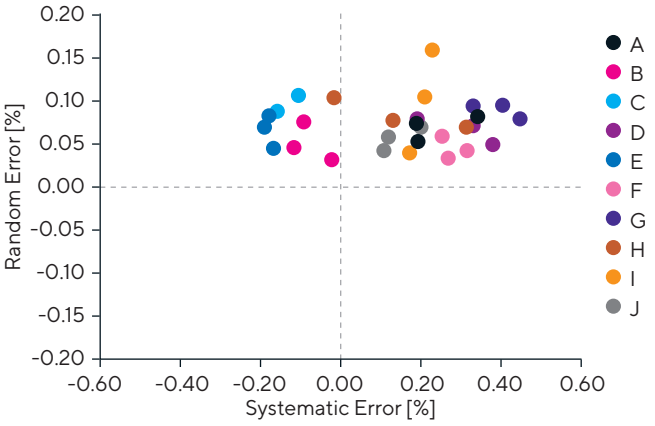

Figure 5: Results of testing using 1000 µL Tacta® at 100% of nominal volume

Tacta® 1000 µL With 10% Volume

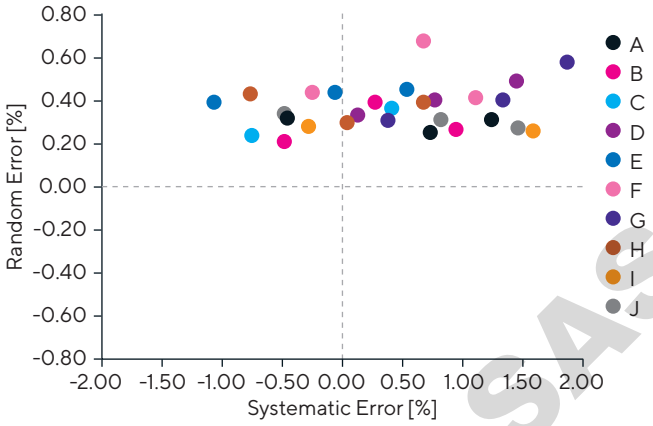

Figure 6: Results of testing using 1000 µL Tacta® at 10% of nominal volume

tips, the sealing area may just be a thin ring around the tip cone. Such a small sealing surface is extremely sensitive to small manufacturing variations like flashes, as well as to small defects in the tip cone, such as scratches caused by repeatedly attaching poorly fitting tips with unnecessarily high force.

It is good to note that there are no specifications or any performance criteria for pipette tips alone. These only exist for pipettes, and these specifications have been written for the pipette and tip combination from the same supplier. The results presented confirm the need to test and validate the results of the pipette and tip system when using a combination supplied from two different manufacturers.

Tip material stability may also have an effect on pipetting performance—especially when tips are autoclaved before use. Low quality tips may deform during autoclaving, influencing pipetting performance. Thus, the evaluation of pipetting performance should always be done with exactly the materials that will be used in the routine pipetting work. The manufacturer's recommendations for tip sterilization should always be followed.

Conclusions

The presented data provides evidence for the statement that pipette and tip act as a system, and the best results will be obtained when using a system with optimal tip fit. The variance in pipetting performance shows that mere physical compatibility is not an indication for high quality pipetting results.

When considering the use of another pipette-tip combination than that recommended by the pipette manufacturer, performance should always be evaluated as part of the supplier selection process. The results also highlight the importance of performing calibration and adjustment when using a pipette-tip system not specified by the pipette manufacturer.

Reference

ISO 8655:2002 Piston-operated volumetric apparatus

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