Thermo Fisher SCIENTIFIC

Pipetting

Improving the functionality and performance of Finntip 10 mL pipette tips

Introduction

In this technical note, we discuss the performance, reproducibility, and ergonomics of pipetting with redesigned 10 mL Thermo Scientific™ Finntip™ Filtered Pipette Tips. We also highlight the benefits of the latest design for our customers.

We at Thermo Fisher Scientific pay close attention to customer suggestions and continually strive to improve our products. Macro-volume pipette tips are routinely used in laboratories that work with liquid volumes of 1–10 mL. In response to customer demand for high-performance macro-volume pipette tips, we redesigned our Finntip 10 mL sterile filtered pipette tips. The redesigned tips enable quick, safe, and efficient handling of larger volumes with outstanding reliability, accuracy, and precision. They have an advanced design that can reach into narrow laboratory culture flasks and reagent bottles to help prevent sample loss. The redesigned Finntip macro-volume pipette tips provide a high level of ergonomic comfort and can help save space in biosafety cabinets when used in lieu of long serological pipettes with bulky motorized controllers.

Product improvements

The following is a comprehensive summary of the improvements made to Finntip 10 mL pipette tips and the benefits they provide.

- The amounts of force required for tip attachment and ejection were reduced by making the upper tip wall thinner and reducing the size of the tip collar. These changes eliminate the need to attach the tips by hand, and reduce the risk of leakage.
- The redesigned tips retain less liquid, which helps prevent sample loss and improves accuracy.
- The diameter of the tip orifice was increased by 58% to make handling highly viscous liquids more efficient. A wider orifice enables faster aspiration and dispensing and enhances the ergonomic benefits of the tips.
- The tips are free of human DNA, RNase, DNase, ATP, endotoxins, and PCR inhibitors. They are suitable for PCR, next-generation sequencing (NGS), and other sensitive molecular biology applications.
- The redesigned tip rack is made of a transparent resin that improves visibility and remains clear even after electron beam sterilization.
- The tip rack was modified with a locking clasp at the front and improved hinges. These modifications help prevent the box from opening when dropped or mishandled, and the box can be opened with one hand.

Here we will refer to the new Finntip 10 mL pipette tips as the redesigned Finntip 10 mL tips, and the preexisting tips as the predecessor tips. We compared the redesigned Finntip 10 mL pipette tips to the predecessor tips by measuring the minimum tip attachment force, minimum tip ejection force, viscous liquid dispensing time, aspiration time, and plunger force. We also compared the accuracy and precision of pipetting with Finntip 10 mL pipette tips and a 10 mL serological pipette.

Methods

Tip attachment force and ejection force

The amount of force applied to attach tips can affect pipetting accuracy and precision. Attachment force is also an important factor to consider when selecting a pipette to minimize the risk of repetitive strain injury. The minimum attachment force is the smallest amount of force needed to attach a tip to a pipette firmly enough to prevent liquid from leaking during use. The smallest amount of force required to eject a tip from a pipette is known as the minimum ejection force. The minimum forces needed to attach and eject the redesigned and predecessor Finntip 10 mL tips were measured using Thermo Scientific™ Finnpipette™ F1 and F2 Variable Volume Pipettes and a Thermo Scientific™ Finnpipette™ Novus Electronic Single-Channel Pipette. Each set of tests was conducted with 10 redesigned and 10 predecessor Finntip 10 mL tips. For comparison, the same tests were conducted with pipettes from two other manufacturers using 10 mL tips recommended by the manufacturers.

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To determine the minimum attachment force, a tip was initially attached to the pipette with ~2 kg of force. Water was aspirated into the tip, and the distal end was monitored for leakage for 20 seconds. The tip was then emptied and wiped by moving the distal end from side to side on the inner wall of the receiving vessel to ensure that any drops on the outside of the tip were transferred to the vessel. After wiping, the same tip was filled with water and evaluated for leakage to check whether wiping loosened it. If the tip did not pass the leak test before and after wiping, the test was repeated with greater attachment force until the tip passed both portions of the leak test. To determine the minimum ejection force, a tip was attached to the pipette with the minimum attachment force. The minimum ejection force was then measured using a Chatillon™ force gauge.

Dispensing viscous liquids

Viscosity is a fluid's resistance to movement relative to its surroundings, or its opposition to flow. To achieve accuracy, special attention is necessary when pipetting viscous liquids. Pipetting speed affects the ergonomic aspects and accuracy of pipetting, and the diameter of the tip orifice influences the pipetting rate. To evaluate the effect of increasing the diameter of the tip orifice on the dispensing rate for viscous liquids, a test was conducted to measure how long it took to dispense viscous liquids with the redesigned and predecessor Finntip 10 mL pipette tips. Solutions containing 25% and 50% glycerol mixed with green dye were used for the test. A 10 mL aliquot of test liquid was aspirated into each tip using the Finnpipette F1 pipette with proper pipetting technique, and the time between the start of dispensing and emptying of the tip was recorded. Measurements were performed with each solution, in duplicate, using a redesigned Finntip 10 mL pipette tip and a predecessor Finntip 10 mL pipette tip.

Plunger force

The plunger of a pipette is its topmost component. It is used to adjust the volume of air in the pipette barrel to allow liquids to be aspirated into the tip and dispensed. Plunger force is the amount of force needed to displace the air in the barrel, which in turn displaces liquid or air in the pipette tip. A Chatillon force gauge was used to measure the plunger forces of the Finnpipette F1 and F2 pipettes and the lower module of the Finnpipette Novus electronic pipette while dispensing deionized (DI) water from a redesigned Finntip 10 mL pipette tip and a predecessor Finntip 10 mL pipette tip. Pipetting was performed using the forward technique. Users encounter two stops when depressing a pipette plunger, one at the set volume and the other at air gap blowout. Plunger force was measured between starting position A and the first stop at position B in this test (Figure 1), although the Chatillon force gauge allowed plunger force to be measured over the entire range of depression from position A to the second stop at position C.

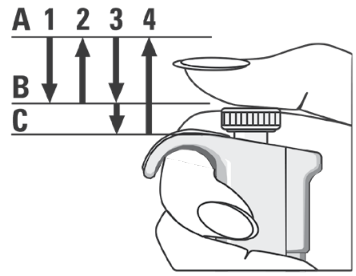


Figure 1. Start and stop positions of a pipette plunger.

Aspiration time

The time needed to draw a set volume of liquid with a pipette is referred to as the aspiration time. Numerous factors affect aspiration time, one of the most important being the pipette tip. The time needed to aspirate 10 mL of DI water using the Finnpipette F1 pipette with the redesigned and predecessor Finntip 10 mL pipette tips was recorded. Each pipette tip was loaded onto the pipette by applying the minimum attachment force. The plunger of the pipette was depressed to the first stop to displace air. The tip was then dipped into the water, and the plunger was released to allow the liquid to freely enter the pipette tip. The time that elapsed between release of the plunger and stabilization of the liquid level in the pipette tip was measured with a stopwatch. Measurements were performed with five redesigned and five predecessor Finntip 10 mL pipette tips. The average aspiration times were compared, and differences were recorded.

Pipetting accuracy and precision with Finntip 10 mL pipette tips and a serological pipette

While serological pipettes are routinely used for volumes greater than 1 mL, they are not ideal for workflows that require high accuracy and precision, because there is a great deal of variation in the volumes pipetted by different users. Macro-volume pipette tips are more reliable options for handling larger volumes of liquid (1–10 mL). We first compared pipetting accuracy and precision using the Finnpipette F1 pipette fitted with a redesigned or predecessor Finntip 10 mL pipette tip. DI water was aspirated and dispensed in volumes of 1 mL, 5 mL, and 10 mL, and 10 measurements were recorded per volume with each tip.

We also evaluated pipetting accuracy and precision with a 10 mL fixed-volume serological pipette. A Thermo Scientific™ S1 Pipette Filler was used to aspirate and dispense water with the pipette in two ways. The first was a multiple dispensing technique that required dispensing to be started and stopped. A 10 mL aliquot of DI water was aspirated into the pipette and dispensed in ten 1 mL increments or two 5 mL increments. Volumes of 1 mL and 5 mL were also aspirated and dispensed multiple times using a single forward dispensing technique. The accuracy of each test was assessed individually, and the results were compared to the manufacturer's specifications and results obtained with the Finnpipette F1 pipette.

Results

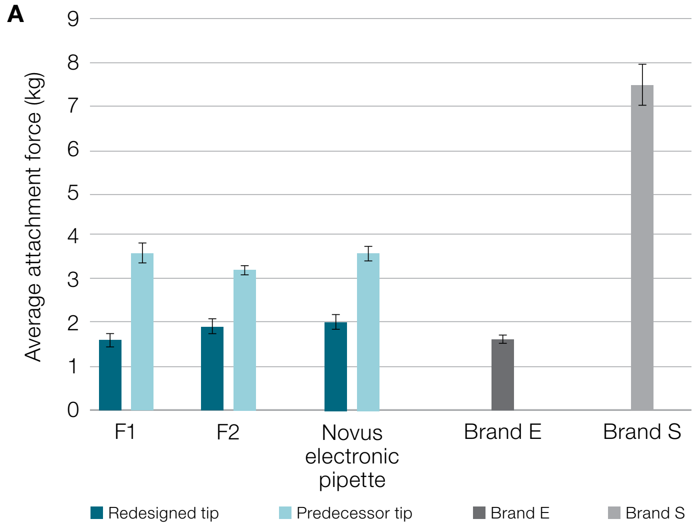
Tip attachment and ejection forces

The attachment force and ejection force of Finnpipette F1 and F2 Variable Volume Pipettes and a Finnpipette Novus electronic pipette were recorded 10 times with 10 different redesigned Finntip 10 mL pipette tips and 10 predecessor Finntip 10 mL pipette tips. The average attachment and ejection forces were then calculated. The average attachment and ejection forces of two other pipettes from different manufacturers were also determined for comparison.

The average force needed to attach the redesigned Finntip 10 mL pipette tips was ~35% lower than the average force needed to attach the predecessor Finntip 10 mL pipette tips (Figure 2A), and the average ejection force was ~15% lower with the redesigned tips. The average attachment forces measured with the brand E pipette and tips and Finnpipette pipettes with redesigned tips were comparable. A statistically significant difference in attachment force was observed with the brand S pipette and tips. The average ejection force measured with the Finnpipette pipettes fitted with redesigned Finntip 10 mL tips was significantly lower ($p < 0.05$) than the ejection forces measured with the brand E and brand S pipettes and tips (Figure 2B). The redesigned Finntip 10 mL pipette tips on the Finnpipette pipettes required on average ~48% and ~63% less force to eject than tips on the Brand E and Brand S pipettes, respectively. The redesigned Finntip 10 mL tips provided a clear ergonomic advantage by requiring less force to attach and eject, which reduced user strain while operating the pipettes.

Dispensing viscous liquids

Dispensing viscous liquids is usually challenging, because it requires skill and patience to do accurately. To make pipetting viscous liquids faster, scientists often cut off the distal ends of their pipette tips to increase the orifice diameter. However, this can result in inaccurate pipetting and greater variability. Dispensing water and viscous liquids from redesigned Finntip 10 mL pipette tips was faster than dispensing from predecessor Finntip 10 mL pipette tips. Enlarging the tip orifice and making the inner surface more hydrophobic improved pipetting efficiency. Dispensing from redesigned Finntip 10 mL pipette tips was 25–50% faster than dispensing from predecessor 10 mL Finntip pipette tips (Figure 3). Individual users noted that the redesigned Finntip 10 mL pipette tips felt lighter due to the reduction in wall thickness, thus adding more ergonomic value.



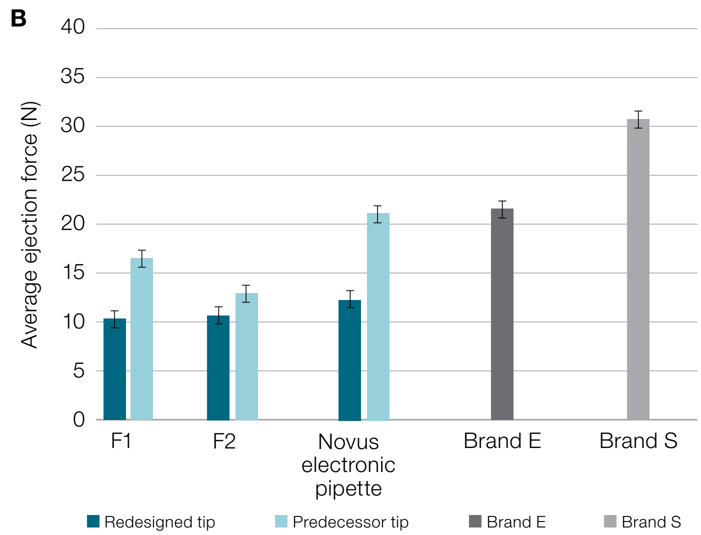


Figure 2. Comparison of attachment force and ejection force on Finnpipette pipettes and pipettes from other vendors. (A) Average attachment force measured with redesigned and predecessor Finntip 10 mL pipette tips on Finnpipette F1, F2, and Novus pipettes and tips and pipettes from two other vendors. **(B)** Average ejection force measured with redesigned and predecessor Finntip 10 mL pipette tips on Finnpipette pipettes and tips and pipettes from other vendors. The bar graphs show the average attachment and ejection forces. The error bars represent ±1 standard deviation.

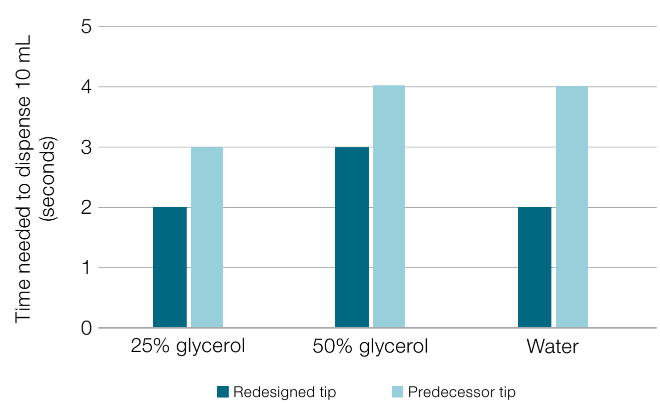


Figure 3. Time needed to dispense liquids of varying viscosity with redesigned and predecessor Finntip 10 mL pipette tips.

Plunger force

Plunger force was measured with redesigned and predecessor Finntip 10 mL pipette tips and compared. Dispensing involved four stages (Figure 1). The three relevant positions were position A at the start of dispensing, position B where the first stop at the set volume was reached, and position C where the stop after air-gap blowout was reached. Plunger force was measured between positions A and B.

The plunger force profiles of all the pipettes tested were comparable (Figure 4). However, dispensing with redesigned Finntip 10 mL pipette tips required slightly less plunger force than dispensing with predecessor Finntip 10 mL pipette tips. Although differences in plunger force measured with the Chatillon pressure gauge seemed minor, a Student's t-test showed that the differences between the plunger forces measured for the redesigned and predecessor Finntip 10 mL pipette tips from the starting position to the first stop were significant ($p < 0.05$) on all three Finnpipette pipettes tested. The redesigned tips made it easier to dispense because less plunger force was required, which reduced user strain.

Aspiration time

The time needed to aspirate 10 mL of DI water was measured from when the pipette plunger was released from the depressed position to when the aspirated liquid stopped filling the tip. Aspiration took 1.1 seconds on average with the redesigned Finntip 10 mL pipette tips, whereas it took an average of 3.21 seconds with the predecessor 10 mL pipette tips (Figure 5). The redesigned 10 mL pipette tips reduced aspiration time by ~65%, indicating they could save customers valuable time in the laboratory.

Pipetting accuracy and precision

The accuracy and precision of dispensing samples and other liquids are critical in most laboratory workflows. We assessed the accuracy and precision of pipetting with a 10 mL serological pipette, a Finnpipette F1 pipette fitted with a redesigned Finntip 10 mL pipette tip, and the same Finnpipette F1 pipette fitted with a predecessor Finntip 10 mL pipette tip. The average accuracy and precision of pipetting 1 mL, 5 mL, and 10 mL DI water were calculated and compared to each other and to the manufacturer's specifications.

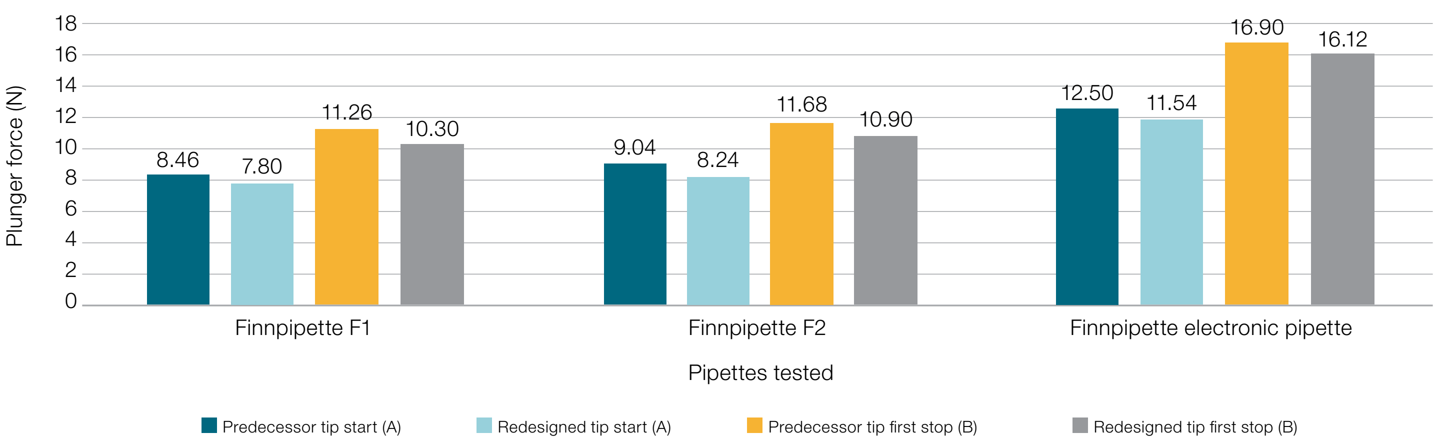


Figure 4. Plunger forces measured with redesigned and predecessor Finntip 10 mL pipette tips. Force was applied from position A at the start of dispensing to the first stop at position B. Differences in plunger force were statistically significant as determined with a Student's t-test.

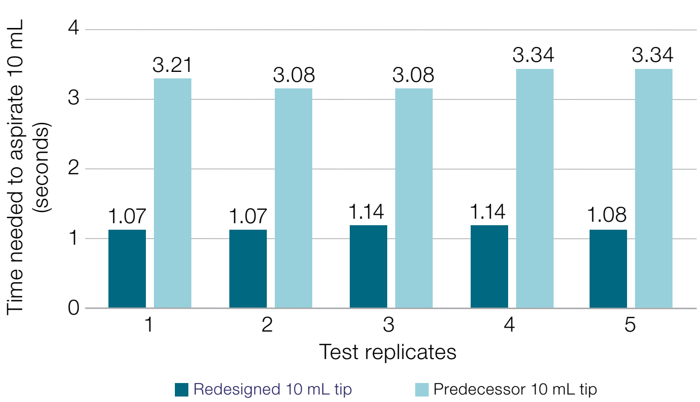


Figure 5. Time needed to aspirate 10 mL of DI water with redesigned and predecessor Finntip 10 mL pipette tips.

Pipetting was most accurate with the redesigned Finntip 10 mL pipette tip, and pipetting with either the redesigned or predecessor Finntip 10 mL tip was more accurate than pipetting with the serological pipette (Figure 6). Far more variability was observed between repetitions when the serological pipette was used for single-aliquot or multi-aliquot dispensing. Dispensing with the serological pipette was thus inconsistent, particularly when smaller volumes were dispensed. The results confirmed that the redesigned Finntip 10 mL pipette tips would be more suitable for work that requires accurate and precise transfer than the predecessor Finntip 10 mL tips or serological pipette.

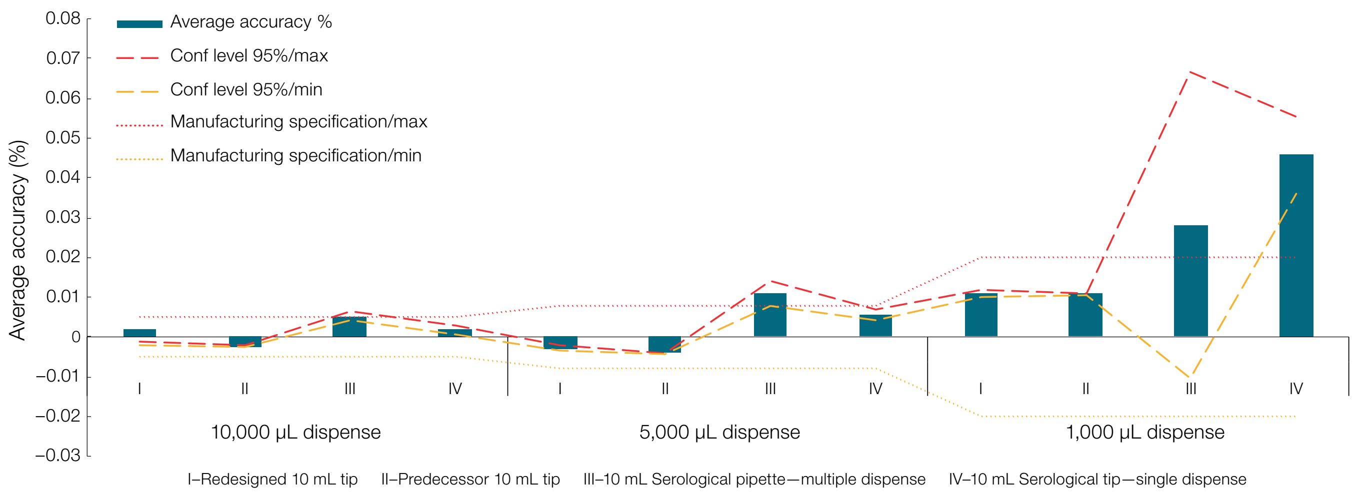


Figure 6. Dispensing accuracy. Dispensing with the redesigned Finntip 10 mL pipette tips was more accurate. The minimum and maximum manufacturing specifications for the redesigned Finntip tips are depicted in the graph. The four tests included: (I) a redesigned Finntip 10 mL tip with the F1 pipette, (II) a predecessor 10 mL tip with the F1 pipette, (III) a 10 mL serological pipette with the S1 Pipette Filler (multiple dispensing with one aspiration), and (IV) a 10 mL serological pipette with the S1 Pipette Filler (single aspiration and dispensing).

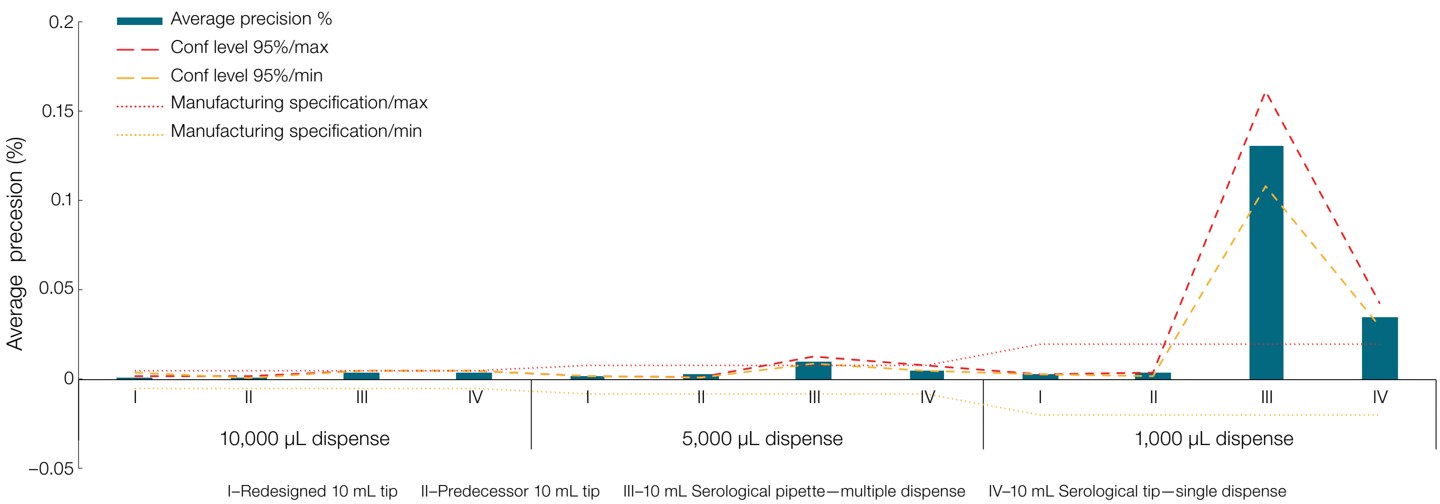


Figure 7. Comparison of dispensing precision with the redesigned Finntip 10 mL pipette tip and a serological pipette. The serological pipette was far less precise, especially when dispensing smaller volumes. The minimum and maximum manufacturing specifications for the redesigned Finntip 10 mL tips are depicted in the graph. The four tests included: (I) a redesigned Finntip 10 mL tip with the F1 pipette, (II) a predecessor 10 mL tip with the F1 pipette, (III) a 10 mL serological pipette with the S1 Pipette Filler (multiple dispensing with one aspiration), and (IV) a 10 mL serological pipette with the S1 Pipette Filler (single aspiration and dispensing).

Quality control

The redesigned Finntip 10 mL pipette tips are manufactured with stringent quality control testing and certified to be free of human DNA, RNase, DNase, endotoxins, ATP, and PCR inhibitors. Each lot of the redesigned tips must satisfy the criteria shown in Table 1. Manufacturing of the redesigned tips complies with the accepted standards for pipette tips used in PCR-based workflows.

Table 1. Certificate of conformity for redesigned Finntip 10 mL sterile filter tips.

Contaminant	Quantity
Human DNA	<30 pg
RNase	$<10^{-9}$ Kunitz/µL
DNase	$<10^{-7}$ Kunitz/µL
Endotoxins	<0.06 EU/µL
ATP	$<10^{-13}$ mg/µL
PCR inhibitors	Free

Conclusions

In response to feedback from our customers, we redesigned Finntip 10 mL pipette tips to improve pipetting performance and efficiency. The redesigned Finntip 10 mL pipette tips reliably dispense volumes of 1–10 mL with more accuracy and precision than serological pipettes. The redesigned tip rack has a modern look and is more transparent, allowing tips to be visible from above without opening the lid. The new resin remains clear and does not yellow even when sterilized under an electron beam. The box can be opened with one hand, and the new clasp and redesigned hinges help keep it closed if it is dropped or mishandled.

In a customer survey conducted during beta testing, all participants noted the updated features and indicated that the form and function of the redesigned Finntip 10 mL tips were superior to those of the predecessor tips. The minimum force needed to eject the redesigned tips is significantly lower than that needed to eject other brands of tips, and the wider tip orifice enables faster aspiration and helps minimize sample loss. The redesigned tips, manufactured under more stringent quality control standards, can be used for cell culture and PCR. These improvements can help increase the productivity of laboratory personnel and overall efficiency of laboratory workflows.

Ordering information

Description	Cat. No.
Finnpipette F1 Variable Volume Pipettes, 1–10 mL	4641120N
Finnpipette F2 Variable Volume Pipettes, 1–10 mL	4642110
Finnpipette Novus Electronic Single-Channel Pipettes, 1–10 mL	46200800
Finntip Filtered Pipette Tips, 10 mL, sterile (predecessor)	94052600
Finntip Pipette Tips, 10 mL, sterile, non-filtered (predecessor)	9402163
Finntip Pipette Tips, 10 mL, non-sterile, non-filtered (predecessor)	9402160
Finntip Pipette Tips, 10 mL, sterile, filtered (redesigned)	94052800
S1 Pipette Fillers	9501
Nunc Serological Pipettes, 10 mL	170355

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