Technical Report

RAININ
Pipetting 360°

Automatic Linearity Correction (ALC)

Improving accuracy

Ideal pipette linearity
Adjustable air-displacement pipettes are designed to deliver a known, user-defined, volume of liquid with a low percentage of error. For mechanical reasons, pipettes can only deliver samples accurately over a limited range of volumes for each particular pipette. For example, a typical 200 µl pipette has a recommended range of 20 to 200 µl. Ideally, the volume of liquid delivered in that range follows a precise linear relationship to the volume dialed on the micrometer. For example, it is expected that setting a 200 µl pipette at 20.0, 100.0 or 200.0 µl it will dispense 20.0, 100.0 or 200.0 µl, respectively.

Nonlinear volume dispensing
Manual pipettes and most electronic pipettes do not deliver liquid linearly across their volume range. This error does not mean that the pipette is not calibrated or unusable. To the contrary, the pipette may be calibrated and capable of delivering liquid within the manufacturer's specification for error. Figure 1 shows typical non-linear response and the percent error associated with a typical 200 µl pipette.

Automatic linearity correction decreases error
RAININ recognizes that systematic error (nonlinear volume dispensing) occurs in most pipettes. It is associated with the physics involved in moving liquids. Systematic error emanates from tip internal diameter, orifice size, size of the air column, and other factors. These systematic errors can be reduced in electronic pipettes, like RAININ's EDP1 and EDP3 models, through corrective adjustments programmed into the circuitry that controls their stepper motors (see RAININ Technical Report *"Stepper motor technology - Higher performance and reliability"* for more detail).

This feature, developed and patented by RAININ, is called Automatic Linearity Correction, or ALC.
The control circuitry is programmed with empirically-determined correction factors for various volume settings throughout the pipette volume range. The correction factor adjusts the number of steps that the motor will move, which also moves the piston, drawing more or less liquid into the tip representative of the correction factor. The pipette then delivers a corrected volume of liquid that better reflects the set volume (see Figure 2) and provides better linearity and accuracy, as shown in Figure 1.

Figure 1

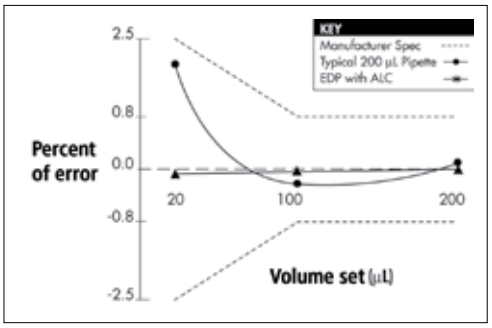

Figure 2
Simplified theoretical example

	Volume Settings		
	20 µl	**100 µl**	**200 µl**
Typical volume delivered before ALC	20.4 µl	99.6 µl	200.5 µl
Nominal # of motor steps before ALC	40	200	400
ALC correction factor (in steps)	-1	+1	-1
Actual # of motor steps after ALC	39	201	399
Actual volume delivered after ALC	19.9 µl	100.1µl	200 µl

Conclusion
RAININ electronic pipettes with Automatic Linearity Correction provide improved accuracy when compared to manual or electronic pipettes without ALC.

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