Application Note

Volumetric Performance Evaluation of the Formulatrix FLO i8® PD Automated Liquid Handling System using the Artel MVS® Multichannel Verification System

Abstract:

The FLO i8® PD is an automated, positive-displacement, independent 8-channel liquid handling platform for general laboratory workflows. In this application note, we report its volumetric performance evaluation using the Artel Multichannel Verification System (MVS), across both contact dispensing (CD) and non-contact dispensing (NCD) modes. FPD50 and FPD1000 tip formats were tested over a combined volume range of 0.2-250 µL, using Aqueous QualAssure solutions, as well as 75% glycerol (v/v) to assess performance with a viscous liquid. Cumulatively, the FLO i8 PD demonstrated relative trueness (RT) of ±1.5% and precision of <3% at all tested volumes, with the sole deviation occurring at the lowest volume (0.2 µL, NCD; 5.62%). Notably, testing with 75% glycerol showed RT and precision of <1%, statistically equivalent to aqueous solutions at matched volumes, without any optimization of liquid handling parameters, indicating viscosity-independent performance. Inter-channel performance was also consistent. These results establish the FLO i8 PD as a versatile solution for general laboratory workflows spanning a broad range of dispensing volumes and liquid properties, including challenging viscous solutions.

1. Introduction



The Formulatrix FLO i8 PD is a general-purpose, 8-channel automated liquid handling system designed for diverse laboratory automation tasks, including serial dilutions, reagent dispensing, plate reformatting, compound management, and assay preparations. The system's positive displacement pipetting method removes air cushion between the liquid and the plunger, making it liquid-class agnostic. This ensures reliable delivery of both water-like and non-water-like viscosity liquids across a dynamic volume range using disposable tips. The 8 channels are independent in volume, span, and z-axis. With the same dispensing head, two interchangeable tip types provide broad volume coverage. The FPD50 tip supports contact dispensing (CD) from 0.5-50 µL and non-contact dispensing (NCD) down to 0.2 µL, while the FPD1000 tip extends volume transfer capacity up to 1000 µL. The 8-channel head is compatible with most tubes, vials, and plates up to 384-well density SBS-footprint labware.

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In this study, we evaluated the volumetric performance of the FLO i8 PD using the Artel MultiChannel Verification System (MVS) (Nova Biomedical; Norwood, Massachusetts), a dual-dye spectrophotometric platform purpose-built for liquid handling verification. The MVS measures absorbance ratios of two co-dispensed dyes, canceling path-length and meniscus effects to report NIST-traceable volumes, accuracy and precision in one measurement run.

2. Materials and Methods

The following instrumentation and materials were used in this study:

- Formulatrix FLO i8 PD liquid handling system
- FPD50 and FPD1000 disposable tips
- Formulatrix Mantis® liquid dispenser
- Artel MVS® Multichannel Verification System
- Artel MVS Verification Plates
- Artel MVS® Aqueous™ QualAssure®
- Artel MVS® QualAssure® Stock Solutions 1/2

Plates were prepared according to the Artel MVS standard protocol. MVS Diluent was pre-dispensed into all wells with Mantis to a final volume of 200 µL. Because the dual-dye method derives volume from an absorbance ratio, the calculated result is insensitive to minor fluctuations in Diluent volumes.

CD was tested using FPD50 for 0.5-50µL and FPD1000 for 10-250µL with Aqueous QualAssure solutions. For viscous liquid handling, 75% glycerol was used as a test liquid at 5 µL and 50 µL with FPD50 and FPD1000, respectively. NCD was evaluated using the FPD50 tip at 0.2 µL and 1 µL, and the FPD1000 tip at 10 µL, all with Aqueous QualAssure solutions. All dispensing parameters were kept at default settings, and experiments were conducted at ambient laboratory temperature.

After dispensing, plates were shaken at 1500 rpm for 60 seconds on included plate shaker to ensure complete mixing of the dyes. The plates were centrifuged briefly and then read on the MVS. Dispensed volumes were calculated from the measured absorbance ratios within the ArtelWare software, yielding results traceable to NIST.

Mean delivered volumes, systematic error (measured as relative trueness, RT), and random error (measured as percentage CV) were calculated to assess volumetric performance. These were calculated for each channel independently, across all replicates within a given run. Replicate counts per channel were n = 4 for all conditions except FPD1000 at 10µL where n=6. Plate-level CV and RT were derived from pooled measurements across all 8 channels (4 or 6 columns per channel, n = 32 or 48 per plate) to analyze both intra-channel and inter-channel variation.

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3. Results and Discussion

3.1. Cumulative volumetric performance

Across most tested conditions, RT remained well within ±1.5%, demonstrating reliable performance. Similarly, precision was high, with CV values <3% across most volumes, indicating excellent liquid handling reproducibility. The CV was 5.62% for NCD at 0.2 µL, which is not unexpected at such a low volume **(Table 1)**.

Mode	Tip	Liquid Type	Reagent	Target (µL)	n	Mean Vol (µL)	RT (%)	CV (%)
CD	FPD50	Aqueous	QualAssure E	0.5	32	0.493	−1.36	2.96
CD	FPD50	Aqueous	QualAssure E	1	32	1.001	+0.15	0.82
CD	FPD50	Aqueous	QualAssure C	5	32	5.061	+1.22	0.35
CD	FPD50	Aqueous	QualAssure A	50	32	50.47	+0.93	0.87
CD	FPD1000	Aqueous	QualAssure B	10	48	10.12	+1.22	1.07
CD	FPD1000	Aqueous	QualAssure A	50	32	49.57	−0.85	0.36
CD	FPD1000	Aqueous	QualAssure HV	250	32	249.81	−0.08	0.32
CD	FPD50	75% Glycerol	Stock Solution 1	5	32	4.975	−0.51	0.34
CD	FPD1000	75% Glycerol	Stock Solution 2	50	32	49.89	−0.02	0.62
NCD	FPD50	Aqueous	QualAssure E	0.2	32	0.1985	−0.73	5.62
NCD	FPD50	Aqueous	QualAssure E	1	32	0.9980	−0.19	0.86
NCD	FPD1000	Aqueous	QualAssure B	10	48	10.028	+0.38	0.76

Table 1. Cumulative volumetric performance of the FLO i8 PD. RT and CV are reported as percentages; n denotes the total number of individual well measurements (8 channels × replicates).

Importantly, the instrument exhibited exceptional volumetric performance for 75% glycerol, with RT and CV values well below 1% at 5 and 50 µL volumes (Table 1). Performance was comparable to that observed with aqueous solutions at the same volumes, without any customization of liquid handling parameters, highlighting the robustness of FLO i8 PD even with challenging liquids.

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3.2. Channel-wise performance

Channel-to-channel performance was highly uniform for CD, with RT range ±4% and CV <2% across all tested volumes **(Table 2 and 3)**. The sole exception was channel 6 at 0.5 µL using FPD50 (CV = 6.05%), which can be attributed to a single outlier measurement.

Channel	FPD50 CV (%)				FPD50 Relative Trueness (%)			
Ch	0.5 µL	1 µL	5 µL	50 µL	0.5 µL	1 µL	5 µL	50 µL
1	0.54	0.17	0.09	0.85	−1.31	0.11	0.93	1.28
2	0.62	0.41	0.25	0.31	−2.08	−0.19	1.02	0.65
3	1.72	0.59	0.11	0.45	−3.81	−0.87	0.83	0.49
4	0.29	0.24	0.27	0.57	−0.10	−0.01	1.12	0.78
5	0.63	0.6	0.19	0.53	−2.43	−0.94	1.12	0.99
6	6.05	0.68	0.28	0.46	3.31	1.27	1.64	1.15
7	1.06	0.17	0.14	0.2	−1.95	0.77	1.55	1.15
8	0.68	0.43	0.34	0.19	−2.52	0.26	1.54	2.57

Table 2. Per-channel CV and RT for CD of Aqueous QualAssure solutions using the FPD50 tip across the 0.5–50 µL volume range.

Channel	FPD1000 CV (%)			FPD1000 Relative Trueness (%)		
Ch	10 µL	50 µL	250 µL	10 µL	50 µL	250 µL
1	1.71	0.19	0.23	0.19	−1.14	−0.12
2	1.96	0.11	0.11	0.7	−0.93	−0.15
3	1.54	0.11	0.22	−0.36	−1.03	−0.37
4	0.66	0.16	0.3	−0.07	−0.87	−0.17
5	1.45	0.39	0.36	−0.85	−0.94	−0.16
6	1.74	0.17	0.22	0.97	−0.38	−0.03
7	1.98	0.17	0.24	0.59	−0.39	0.06
8	1.72	0.37	0.46	−0.60	−1.16	0.32

Table 3. Per-channel CV and RT for CD of Aqueous QualAssure solutions using the FPD1000 tip across the 10–250 µL volume range.

Overall, consistent performance was observed across channels for NCD, with RT ±3.5% at the minimum target volume of 0.2 µL and <1.0% at 1 and 10 µL. Precision was also robust, as all channels demonstrated CV <1.25% at 1 and 10 µL **(Table 4)**. The lower precision (CV <7.5%) at 0.2 µL is attributable to the low-end boundary volume.

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Channel	CV (%)			Relative Trueness (%)		
	FPD50 0.2 µL	FPD50 1 µL	FPD1000 10 µL	FPD50 0.2 µL	FPD50 1 µL	FPD1000 10 µL
1	4.75	0.29	0.74	−2.44	+0.13	+0.16
2	3.63	1.24	0.55	−1.89	−0.93	+0.43
3	1.73	1.24	0.87	−1.88	−0.47	+0.22
4	2.04	0.90	0.78	−3.26	−0.42	+0.34
5	1.77	1.01	0.88	−0.86	+0.01	+0.31
6	7.33	0.97	1.10	−2.71	+0.02	+0.33
7	6.67	0.17	0.89	−3.39	−0.35	+0.22
8	2.25	0.20	0.54	−3.05	+0.37	+0.22

Table 4. Per-channel CV and RT for NCD of Aqueous QualAssure solutions using the FPD50 tip at 0.2 µL and 1 µL, and the FPD1000 tip at 10 µL.

4. Conclusion

Under tested conditions, the FLO i8 PD demonstrated accurate, precise, and consistent liquid handling across a broad working volume range, with particularly strong performance at target volumes ≥1 µL. Performance remained uniform across channels in both CD and NCD modes, supporting reproducible multichannel transfer across diverse workflows. Notably, enabled by positive displacement technology, the FLO i8 PD handles both viscous and non-viscous solutions without any liquid-specific optimization. Together, these capabilities make the FLO i8 PD a versatile solution for precision-critical, low-volume applications.

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This work was carried out by Formulatrix in collaboration with Nova Biomedical. The Artel product portfolio is the global technology leader in low-volume liquid delivery measurement and quality assurance. The company develops and manufactures highly accurate, precise, and easy-to-use systems to ensure liquid delivery data integrity and NIST-traceable results in life sciences laboratories. Artel innovations help laboratories improve processes and increase productivity, enhance product quality, and address compliance challenges.

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