High Dispense Repeatability for Varying Fluid Viscosity Provided by IntelliGen® MV Dispense System

Authors: Mitsutoshi Ogawa, Wilson Hsu, and Kanjanawadee Shiraishi, Entegris, Inc.

ABSTRACT

To dispense a highly viscous fluid, especially in a small volume, is one of difficult operations that engineers need to deal with in an industrial process. In this condition, only a slight fluctuation in temperature can dramatically affect the volumetric flow rate of a dispensed liquid due to the expansion and contraction of the liquid caused by ambient temperature, which consequently results in a difficulty to control the liquid volume.

Besides the control of liquid volume, high pressure generated during the dispense of mid-viscosity fluid is another issue that mitigation is required.

In this application note, two sorts of data are demonstrated; 1) the repeatability of the dispense volume of the IntelliGen® MV (IG-MV) and 2) the pressure generated in the dispense chamber during the dispense period.

The first sort data shows that the IG-MV is able to repeatedly deliver the liquid volume of varying viscosities, 200 cP to 1000 cP even under the uncontrolled-temperature environment. The dispensed liquid volume fluctuates in the range of 3 sigma ≤0.03 g.

The second sort data show that none of test condition generates the pressure over 60 psi inside the dispense chamber.

According to the evaluation results, the IG-MV should be a capable tool for the dispense of mid-viscosity fluid.

EXPERIMENTATION

Testing was performed in Entegris facility. The experiment used Isopropyl alcohol (IPA) and Glycerol blending to obtain the viscosity of interest. The mixtures of IPA and Glycerol ranging from 200 cP to 1000 cP were prepared. IG-MV pump installed with an Impact® 2 V2 0.5 µm was used to dispense those blended liquids. The dispense rate of 0.5 mL/s was used throughout the testing. The IG-MV dispensed 300 cycles and the dispensed liquid weight of each dispense was measured by electric balance. Then, by using a 300-dispense-cycle data points, the 3 sigma values were calculated in order to determine the repeatability of the dispensed liquid. The testing was conducted in the environment where the temperature is not thoroughly controlled. The ambient temperature of the testing rig varied from 21 to 25 degrees Celsius.

Besides the dispensed liquid weight, the average dispense pressure and the maximum dispense pressure during the dispense period were also recorded in order to determine the over pressure issue of the IG-MV dispense system. Pressure of 60 psi is the limit of pressure allowed to be generated inside dispense chamber.

Table 1 summarizes the setting parameters of the IG-MV during the testing.

Table 1. Summary of pump parameters used for dispensing each liquid viscosity

NO.	PUMP SETTING PARAMETER	200 CP	300 CP	400 CP	500 CP	600 CP	700 CP	800 CP	900 CP	1000 CP
1	Vent frequency	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	Vent volume (mL)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
3	Vent rate (mL/s)	0.50	0.50	0.20	0.20	0.20	0.10	0.10	0.10	0.10
4	Purge volume (mL)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
5	Purge rate (mL/s)	0.50	0.50	0.20	0.20	0.20	0.10	0.10	0.10	0.10
6	Fill rate (mils)	0.30	0.30	0.15	0.15	0.10	0.10	0.20	0.20	0.10
7	Filtration rate (mils)	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.15
8	Maximum dispense volume (mL)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
9	Filtration pressure (psi)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
10	Open adjustment (ms)	350	300	410	390	500	600	600	600	600
11	Close adjustment (ms)	0	0	200	600	1000	1000	1000	1000	1000
12	Dispense volume (mL)	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
13	Dispense rate (mL/s)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
14	Volume calibration (mL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TESTING SETUP

The details of testing setup are shown in Figure 1.

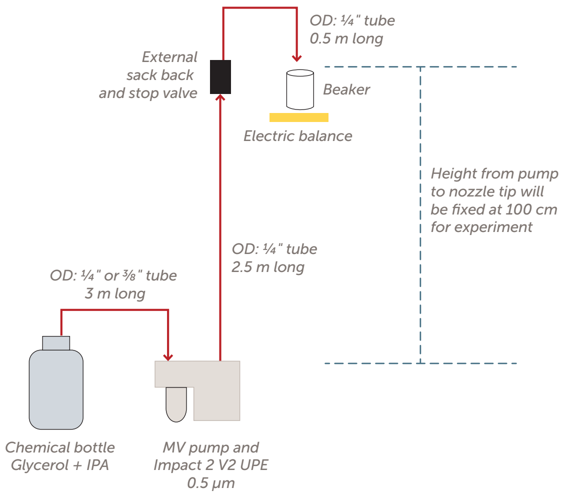

Figure 1. Details of testing setup.

TEST RESULT

1. Dispense Repeatability of the IntelliGen MV

Figure 2 is a summary of 3 sigma value of each liquid viscosity. The test results show that 3 sigma value of every liquid viscosity is less than 0.03 g. The "3 sigma ≤0.03 g" is not a specification limit. It is the result obtained from the evaluation testing.

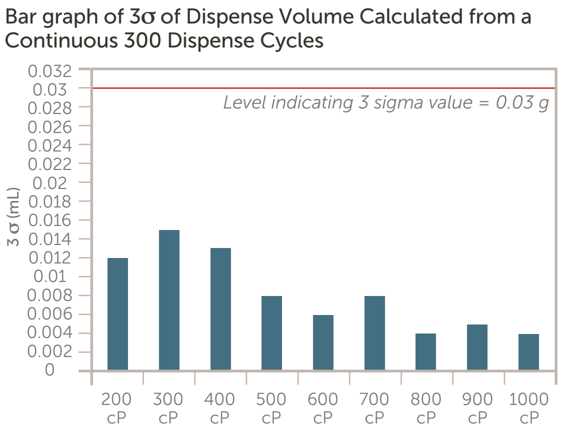

Figure 2. Summary of 3 sigma value of each liquid viscosity.

Figures 3 through 11 show two types of plots; dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red). The two yellow horizontal lines located in each figure indicate the range of 0.03 g. The nine figures confirm a very high dispense repeatability of the IG-MV. The dispensed liquid weight remains within the 0.03 g fluctuation range while the ambient temperature dramatically fluctuates.

Plots of Dispensed Liquid Weight and Ambient Temperature vs. Dispense Cycle of 200 cP Liquid

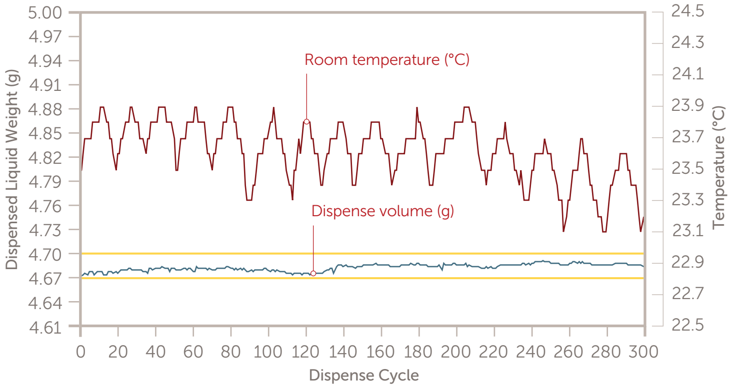

Figure 3. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 200 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs. Dispense Cycle of 300 cP Liquid

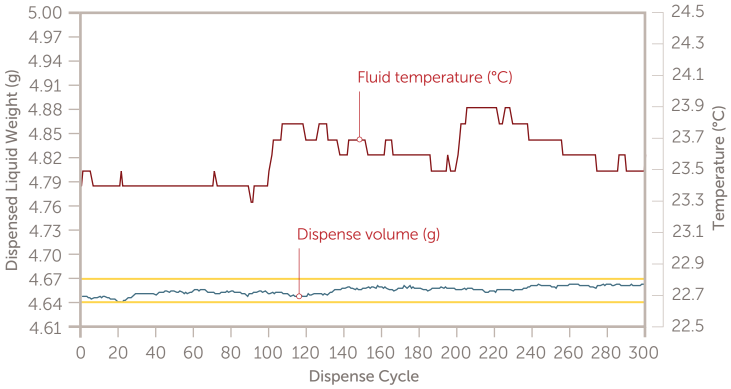

Figure 4. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 300 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs. Dispense Cycle of 400 cP Liquid

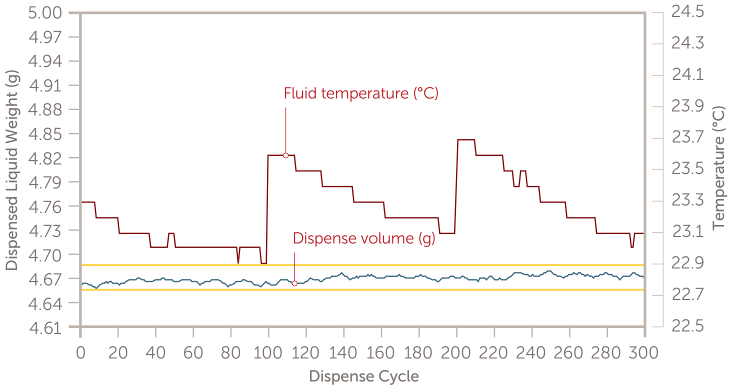

Figure 5. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 400 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs.
Dispense Cycle of 500 cP Liquid

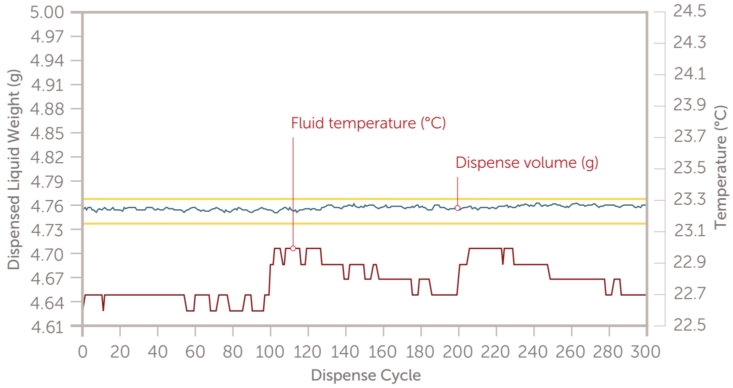

Figure 6. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 500 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs.
Dispense Cycle of 600 cP Liquid

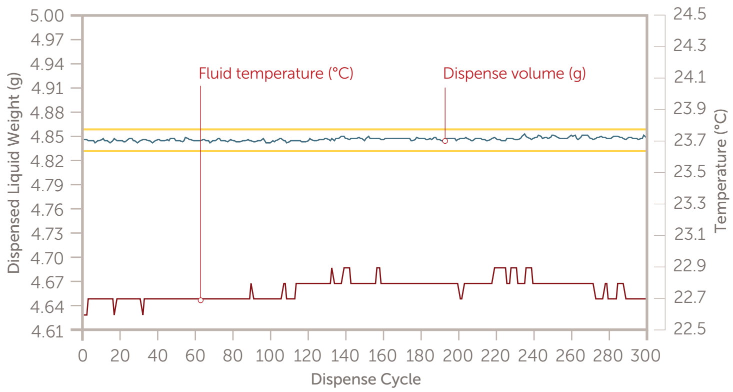

Figure 7. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 600 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs.
Dispense Cycle of 700 cP Liquid

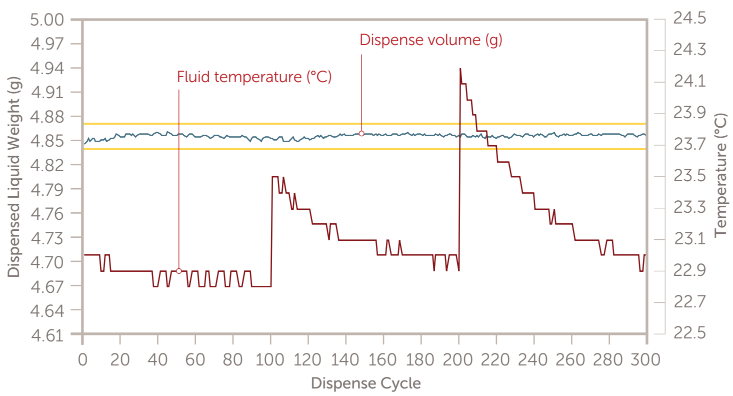

Figure 8. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 700 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs. Dispense Cycle of 800 cP Liquid

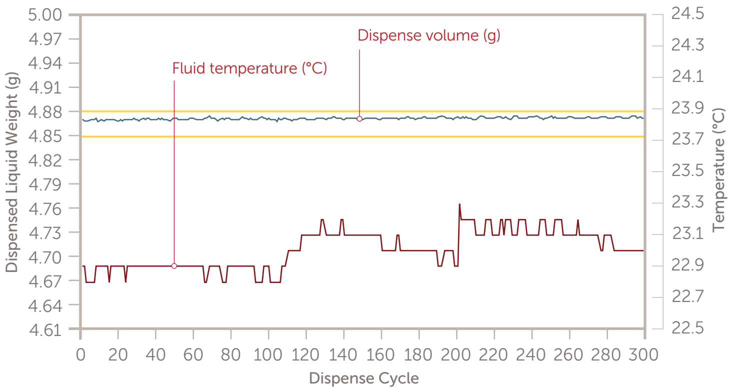

Figure 9. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 800 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs. Dispense Cycle of 900 cP Liquid

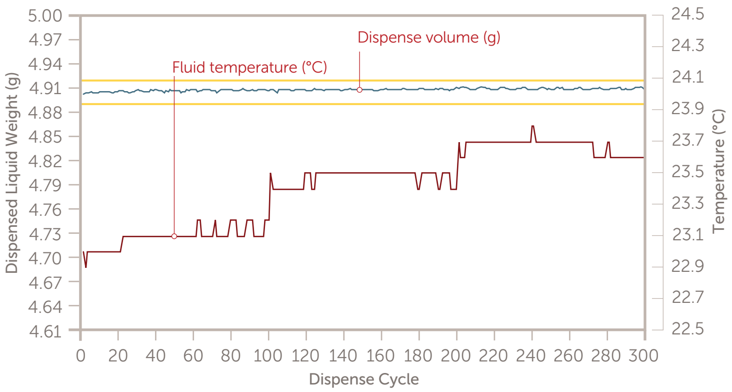

Figure 10. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 900 cP liquid.

Plots of Dispensed Liquid Weight and Ambient Temperature vs. Dispense Cycle of 1000 cP Liquid

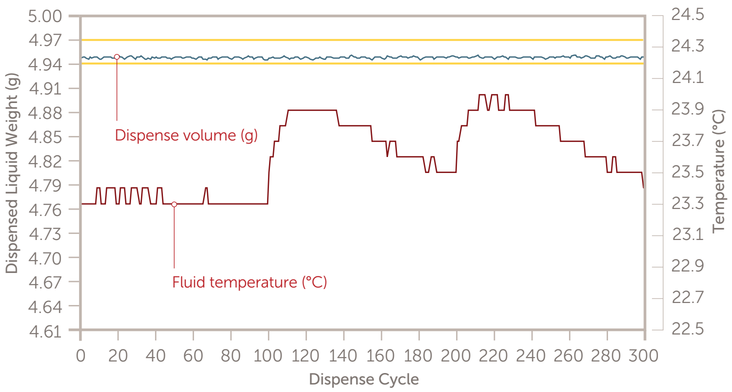

Figure 11. Plots of dispensed liquid weight versus dispense cycle (blue) and ambient temperature versus dispense cycle (red) of 1000 cP liquid.

2. Pressure generated inside dispense chamber during the dispense period

During dispense period, the dispense piston advances to push liquid through outlet. Relatively high pressure is usually generated right before the outlet valve opens. Afterward, a lower but constant pressure appears. Figure 12 demonstrates an example of the change of pressure with respect to time during the dispense period of 200 cP liquid. The recorded average dispense pressure and maximum dispense pressure of every liquid viscosity are summarized in Table 2.

Pressure Profile During Dispense Section of 200 cP Liquid

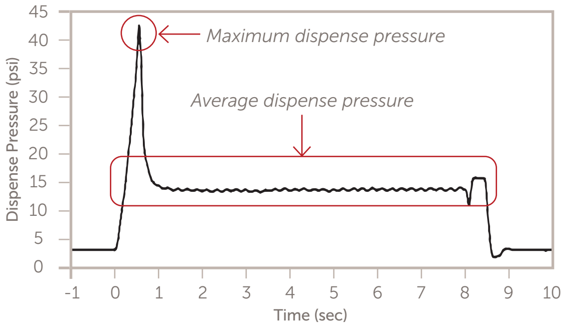

Figure 12. Plot of pressure versus time during dispense period.

Table 2. Summary of average dispense pressure and maximum dispense pressure when each viscosity is dispensed with 0.5 mL/s dispense rate

VISCOSITY (CP)	AVERAGE DISPENSE PRESSURE	MAXIMUM DISPENSE PRESSURE
200	14.25	42.24
300	16.95	21.88
400	17.26	26.81
500	22.23	28.38
600	27.58	33.25
700	29.55	45.85
800	33.56	45.26
900	38.03	49.67
1000	41.05	52.86

According to the data shown in Figures 2 through 11 and Table 2, the following interpretations can be made:

1. The plots of dispensed liquid weight versus dispense cycle show a consistence of data despite the fact that the testing was conducted under the situation where the ambient temperature fluctuates from 21 degree Celsius to 25 degree Celsius. This implies that the IG-MV would have given a higher capability if it was placed in the environment where the stable pressure is controlled.
2. The average dispense pressure and the maximum dispense pressure in Table 2 show that none of test condition makes the dispense pressure goes beyond the limit (60 psi) even when the IG-MV dispenses a 1000 cP liquid.

CONCLUSION

In spite of the fluctuation of temperature, the IG-MV showed that it is able to deliver a consistent liquid volume. In addition, it does not generate a very high pressure during dispense. With this good dispense repeatability and moderate dispense pressure, the IG-MV should be the dispense system which is able to provide a capable process in chip-manufacturing and an ease in handling. Less attempt would be required for manufacturers to obtain a higher performance of the production process.

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PURE ADVANTAGE

Corporate Headquarters
129 Concord Road
Billerica, MA 01821
USA

Customer Service
Tel +1 952 556 4181
Fax +1 952 556 8022
Toll Free 800 394 4083