Calibration of Mechanical Volumetric Liquid-Dispensing Devices Procedure

A laboratory may use the following method for the gravimetric determination of measurement error of mechanical volumetric liquid-dispensing devices (e.g., fixed and adjustable auto-pipettors, bottle-top dispensers, etc.) used to dispense volumes greater than or equal to 100 µl.

Apparatus and Equipment

Weighing vessel (of sufficient capacity to hold all volumes dispensed for the test and a 3:1 height-to-diameter ratio is recommended to minimize evaporation)
Reagent water (e.g., distilled or deionized water)
Analytical balance (accurate to 0.0001 g for 100 µl to 10 ml, and accurate to 1 mg for 10 ml to 200 ml dispensed volumes)
Calibrated thermometer (graduated, at a minimum, in 0.5 °C increments)

Documentation Requirements

- Date performed
- Analyst performing the test
- Unique identifier (e.g., serial number, etc.)
- Manufacturer's specification of accuracy
- Balance test-weight reading
- Volumes tested
- Volume weights observed
- Reagent water used is at ambient temperature
- All calculations used to assess accuracy

Procedure

1. Allow apparatus and reagent water to equilibrate to room temperature.
2. Check the calibration of the balance.
3. Wet the liquid-dispensing device and lubricate the piston insuring smooth operation by pipetting several volumes to waste.
4. Weigh the vessel and tare the balance.
5. Dispense a minimum of five aliquots of water into the vessel, weighing and recording the mass for each replicate.
6. Calculate the following:

   m = **mean mass** = total of individual weight measurements ÷ total number of measurements

   Z = **Z correction factor** obtained from Table 1 using the temperature of the test liquid and current barometric pressure.

   V = **volume equivalent (or corrected volume) of mass measured** = m * Z

   RE = **relative error** (%) = $\frac{[Vm - Vo]}{Vo} * 100$

   where:

   Vm = **corrected mean volume** = total of corrected volumes ÷ total number of dispensed volumes

   Vo = **nominal or test volume**

S = **standard deviation** = For each replicate, subtract the mean volume from the corrected volume, then square the value. Sum the squared values of all replicates, and then divide the sum by n-1 (the number of measurements minus 1). Take the square root of this value to get the standard deviation.

CV = **coefficient of variation** (%) = $\frac{s}{Vm} * 100$

To simplify this process, spreadsheets for calculating and documenting the relative error and coefficient of variation can be found on the NC Wastewater/Groundwater Laboratory Certification Branch (NC WW/GW LCB) website.

The Relative Error (a measure of accuracy) and Coefficient of Variation (a measure of precision) must not be greater than the manufacturer's specifications. If the results are greater than the manufacturer's specification, repeat the procedure. If the results remain greater, follow the manufacturer's instructions for maintenance and adjustment and repeat the procedure. If repeated calibration attempts do not yield results within the manufacturer's specifications, the liquid-dispensing device must be repaired or replaced.

Note: Microliter pipettors may need to be tested under more rigorously controlled conditions or sent to a calibration service for testing. Since most analytical balances used in environmental laboratories read to only four decimal places, it may be necessary, when checking microliter pipettors (less than 1000 µl), to include the weight of the weighing vessel in each replicate and subtract it and subsequent aliquots out manually in order to have a measurable mass for the purpose of this verification. Contact your auditor if you have questions.

Table 1. Z Correction Factor Table.

Temperature °C	Air pressure, kPa (mbar)						
	80 (800)	85 (850)	90 (900)	95 (950)	100 (1000)	101.3 (1013)	105 (1050)
15.0	1.0017	1.0018	1.0019	1.0019	1.0020	1.0020	1.0020
15.5	1.0018	1.0019	1.0019	1.0020	1.0020	1.0020	1.0021
16.0	1.0019	1.0020	1.0020	1.0021	1.0021	1.0021	1.0022
16.5	1.0020	1.0020	1.0021	1.0021	1.0022	1.0022	1.0022
17.0	1.0021	1.0021	1.0022	1.0022	1.0023	1.0023	1.0023
17.5	1.0022	1.0022	1.0023	1.0023	1.0024	1.0024	1.0024
18.0	1.0022	1.0023	1.0023	1.0024	1.0025	1.0025	1.0025
18.5	1.0023	1.0024	1.0024	1.0025	1.0025	1.0026	1.0026
19.0	1.0024	1.0025	1.0025	1.0026	1.0026	1.0027	1.0027
19.5	1.0025	1.0026	1.0026	1.0027	1.0027	1.0028	1.0028
20.0	1.0026	1.0027	1.0027	1.0028	1.0028	1.0029	1.0029
20.5	1.0027	1.0028	1.0028	1.0029	1.0029	1.0030	1.0030
21.0	1.0028	1.0029	1.0029	1.0030	1.0031	1.0031	1.0031
21.5	1.0030	1.0030	1.0031	1.0031	1.0032	1.0032	1.0032
22.0	1.0031	1.0031	1.0032	1.0032	1.0033	1.0033	1.0033
22.5	1.0032	1.0032	1.0033	1.0033	1.0034	1.0034	1.0034
23.0	1.0033	1.0033	1.0034	1.0034	1.0035	1.0035	1.0036
23.5	1.0034	1.0035	1.0035	1.0036	1.0036	1.0036	1.0037
24.0	1.0035	1.0036	1.0036	1.0037	1.0037	1.0038	1.0038
24.5	1.0037	1.0037	1.0038	1.0038	1.0039	1.0039	1.0039
25.0	1.0038	1.0038	1.0039	1.0039	1.0040	1.0040	1.0040
25.5	1.0039	1.0040	1.0040	1.0041	1.0041	1.0041	1.0042
26.0	1.0040	1.0041	1.0041	1.0042	1.0042	1.0043	1.0043
26.5	1.0042	1.0042	1.0043	1.0043	1.0044	1.0044	1.0044
27.0	1.0043	1.0044	1.0044	1.0045	1.0045	1.0045	1.0046
27.5	1.0045	1.0045	1.0046	1.0046	1.0047	1.0047	1.0047
28.0	1.0046	1.0046	1.0047	1.0047	1.0048	1.0048	1.0048
28.5	1.0047	1.0048	1.0048	1.0049	1.0049	1.0050	1.0050
29.0	1.0049	1.0049	1.0050	1.0050	1.0051	1.0051	1.0051
29.5	1.0050	1.0051	1.0051	1.0052	1.0052	1.0052	1.0053
30.0	1.0052	1.0052	1.0053	1.0053	1.0054	1.0054	1.0054

Z correction factors are for distilled water as a function of liquid test temperature and air pressure.
Z values are in microliters per milligram.

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If your laboratory does not have a mercury barometer, the true local barometric pressure for locations throughout North Carolina may be obtained from the North Carolina State University, State Climate Office of North Carolina website at http://www.nc-climate.ncsu.edu/.