ACCURACY AND PRECISION OF THE CLASS A BURET

Quantitative chemical analysis in general, and the introductory laboratory course specifically, make substantial use of the buret for the delivery of precise volumes of liquids. It is important to understand the accuracy and precision that we can expect from the buret.

The buret is simply a glass cylinder. If the cylinder is of constant diameter throughout its length, the volume contained in the buret between two markings separated by a distance s will be given by $V = \pi d^2 d/ 4$ where d is the inside diameter of the cylinder. This has the effect of converting the measurement of a 3 dimensional property into a one dimensional quantity.

Insuring the uniformity of the diameter of the manufactured buret is a non-trivial fabrication problem. We address it by recognizing the industry standards. The American Society for Testing Materials (ASTM) maintains a series of standards for the manufacture of glass burets. Its standard E287[1] addresses the refinement of the scale divisions, length of the scale, volumetric tolerance, and minimum delivery time. There are two classifications of burets – A and B. The tolerances in delivered volumes for 50 mL burets are 0.05 mL for class A and 0.10 mL for class B**.**

The burets provided in the introductory lab course are class A. So, for measurements of volumes of 25 mL, the intrinsic percent uncertainty in the delivered volume (with a tolerance of 0.05 mL) is 0.2 %. Intrinsic means with no error introduced by the experimenter.

What kinds of error can the experimenter introduce in addition?

Reading errors.

The scale of the 50 mL buret has markings at 0.1 mL intervals which represent 0.4 % in a delivered volume of 25 mL – twice the specified tolerance. To minimize this uncertainty, we use a rule of thumb to improve the precision of the buret reading.

Rule of Thumb

> The human eye can estimate the location of a point in an interval between two marked divisions *on a linear scale* to the nearest $1/5^{th}$ of the distance between the divisions.

The rule assumes that the division marks are narrow compared to the interval. In our case, the rule of thumb is equivalent to having virtual marks at 0.02 mL which represents a percent error of < 0.1 % - well below the intrinsic error.

[1] http://www.astm.org/Standards/E287.htm

Other sources pf error.

Most of the remaining sources of error are in the reading of the liquid level in the buret – such as identifying the liquid meniscus and minimizing parallax errors by adjusting the eye level to the level of the meniscus.

The point at which we stop adding a liquid from a buret usually is determined by a signal of some sort – some change in a chemical or physical property of the system to which the liquid is added. Such errors are NOT associated with the buret.

Like any glass device, when a buret is filled with a liquid, some of the liquid adheres to the glass walls. It takes some time for that liquid to flow entirely down to the level of the meniscus – the boundary between the liquid and gas phases. For that reason, we do not try to set the liquid level to a specified precise volume. We allow the adhered liquid to settle and then read the location of the meniscus. For that reason:

an initial buret reading can be 0.00 mL only by accident.

It is safest and proper practice to always let the starting level be somewhere between 0.00 and 5.00 mL.

Since the buret **delivers** a precisely known volume, both an initial and final level of the buret must be determined. That will double the percent error associated with a single reading.

Clearly, the percentage errors in delivered volumes are inversely proportional to the volume delivered. E.g., If the error in a single reading is 0.02 mL, the error in the delivered volume will be 0.04 mL. This represents an error of 0.04 % in 10 mL , 0.08 % in 20 mL and 0.12% in 30 mL. Such an error represents 0.1 % error in 25 mL. This is the level of precision that we would like to achieve in most of the quantitative exercises in CHE 133 and CHE 134.

If volumes are read and recorded with care, the buret is able to deliver arbitrary volumes of liquids with high precision.