United States Environmental Protection Agency

Calculated Flush Time (CFT) or Calculated Flush Volume (CFV) Approach for Representative Distribution System Chlorine and Disinfection Byproduct (DBP) Sample Collection from Building Taps

Objective: This guidance document provides details on best practices to consistently and accurately assess drinking water disinfectant residual and disinfection byproduct (DBP) concentrations in samples collected from building taps in order to characterize water quality in the distribution system main. Under-flushing prior to sampling may result in characterizing water quality from the service line, which may not be representative of the water quality in the distribution system main, and this is a common issue in some businesses or larger buildings with larger diameter and longer length service lines. Over-flushing may unnecessarily waste a consumer's water. The CFT/CFV approaches were developed to ensure a consistent, fundamentally sound approach to collecting samples from building taps.

The CFT/CFV is determined based on estimates for the total length of line (including exterior service line and indoor plumbing), the internal diameter (ID) of line(s), and flow rate through the tap using the following approach.

1. **Estimate the ID of each segment of the line (both inside and outside of the building),** considering the following:
   a. Commonly, the ID of a residential service line is ¾"
   b. If the water meter is visible, it will typically indicate the ID of the buried service line and premise plumbing (e.g., ¾", 1", 2"); assume the ID of the service line and premise plumbing are the same unless a visible difference is observed.
   c. If the water meter is not visible, locate where the service line enters the building (e.g., basement, utility closet) and estimate the ID of the line.
   d. The wall thickness of pipes varies based on pipe material (e.g., lead pipes are typically thicker than copper pipes).
2. **Estimate the total length of the line outside of and inside the building**, possibly utilizing a distribution system map:
   a. Generally, the line runs from the main, through a curb stop (shutoff valve), and directly into the building or meter.
      i. Sometimes the service line will enter the building through the back or side.
      ii. A map may indicate the main location in the absence of other information (i.e., visible curb stop, hydrant orientation, operator knowledge).
   b. Select a sample tap near where the service line enters the building to minimize the amount of indoor plumbing to be flushed. Determining the length and diameter of indoor plumbing can be difficult which is why a safety factor is applied to the calculation.
   c. Measure the distance between the water main and where the line enters the building and the additional distance to the sample tap.
3. **Determine the CFT (at 2 gpm) or CFV for each segment of pipe using Table 1 (time) or Table 2 (volume), respectively, sum the times (or volumes) and apply a 2-fold safety factor to account for any unidentified line**, as shown in the examples below.
   Round the pipe length to the nearest value and extrapolate or interpolate for any lengths not specifically listed in the table.

<u>**CFT**</u>
100' + 25' of 3/4" ID line ➔ 1.1 + 0.3 minutes = 1.4 minutes
+ 52' of ½" ID line (round to 50') ➔ + 0.3 minutes
= Total **CFT @ 2 gpm** = 1.7 minutes × 2 (safety factor) = **3.4 minutes**

<u>**CFV**</u>
100' + 25' of 3/4" ID line ➔ 2.3 + 0.6 gallons = 2.9 gallons
+ 52' of ½" ID line (round to 50') ➔ + 0.5 gallons
= Total **CFV** = 3.4 gallons x 2 (safety factor) = **6.8 gallons**

4. **Flush the tap, removing aerator before sampling from the tap (if applicable)**
    a. *If flush time is used*, turn on the tap and start a timer. Then check the flow rate. If it is significantly different than 2 gpm, adjust the CFT using the following equation.

$$CFT_{actual\ flow\ rate} = Total\ CFT_{@\ 2gpm} \times \frac{2\ gpm}{actual\ flow\ rate,gpm}$$

Adjusting the earlier CFT example for 5 gpm flow rate ➔ $CFT_{5\ gpm} = 3.4\ minutes\ \times \frac{2\ gpm}{5\ gpm} = 1.4\ minutes$

    b. *If volume measurement is used*, flush the line for the proper amount of volume using an appropriate measuring device.

5. After the tap has flushed for the CFT/CFV, **collect and analyze the sample** for the desired parameters (e.g., chlorine, pH, temperature). Note: the CFT/CFV only has to be determined once for each sampling location and the result can then be used routinely as long as the flow rate during the flushing is relatively consistent from one sample event to another.

Equipment Needed to Determine CFT/CFV

- Measuring device (i.e., cup, bucket, meter setup) – to measure flushed volume and/or flow rate; recommend 4-cup (32 oz.) or larger to allow sufficient fill volume over a reasonable time-frame (i.e., at a 2 gpm flow rate, the tap fills 32 oz. in 7.5 seconds)
- Stopwatch/Timer – to measure flush duration
- Tape measure or distance wheel – to measure length of line

Table 1: Calculated Flush Times (minutes) at 2 gpm for Various Line Sizes (inner diameter, ID, provided in inches)

Line Length (feet)	3/8" ID	½" ID	¾" ID	1" ID	1 ½" ID	2" ID	2 ½" ID	3" ID	4" ID
5	0.01	0.03	0.1	0.1	0.2	0.4	0.6	0.9	1.6
10	0.03	0.1	0.1	0.2	0.5	0.8	1.3	1.8	3.3
25	0.1	0.1	0.3	0.5	1.1	2.0	3.2	4.6	8.2
50	0.1	0.3	0.6	1.0	2.3	4.1	6.4	9.2	16.3
100	0.3	0.5	1.1	2.0	4.6	8.2	12.7	18.4	32.6

Note: some water systems and state primacy agencies have applied a **5-minute flush time** before sample collection. This may be excessive, appropriate, or insufficient depending on the circumstances at that sample point.

Table 2: Calculated Flush Volume (gallons) for Various Line Sizes (inner diameter, ID, provided in inches)

Line Length (feet)	3/8" ID	½" ID	¾" ID	1" ID	1 ½" ID	2" ID	2 ½" ID	3" ID	4" ID
5	0.03	0.1	0.1	0.2	0.5	0.8	1.3	1.8	3.3
10	0.1	0.1	0.2	0.4	0.9	1.6	2.5	3.7	6.5
25	0.1	0.3	0.6	1.0	2.3	4.1	6.4	9.2	16.3
50	0.3	0.5	1.1	2.0	4.6	8.2	12.7	18.4	32.6
100	0.6	1.0	2.3	4.1	9.2	16.3	25.5	36.7	65.3

Note: this approach is not dependent on the sample tap flow rate, but an approach for measuring volume is needed (i.e., appropriate measuring device).