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

Objective: Flushing practices, prior to sample collection, are generally inconsistent throughout the drinking water industry. In order to accurately assess disinfectant residual and disinfection byproduct concentrations (DBPs), for both compliance and optimization purposes, an approach for collecting samples that characterize water quality in the distribution system main is needed. Under-flushing prior to sampling may result in characterizing water quality from the service line which can adversely impact the results, while over-flushing is not necessary. The CFT/CFV approaches were developed to ensure a consistent, fundamentally sound approach to collecting samples from building taps that are routinely used (i.e., compliance or optimization sample locations).

The CFT/CFV is based on the total length of line (including exterior service line and indoor plumbing), the interior diameter (ID) of line(s), and flow rate through the tap using the following approach. Additionally, a distribution system operator can be an excellent resource for this activity.

1. Estimate the ID 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 both inside and outside of 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.
   c. Measure the distances between the water main and where the line enters the building and the additional distance to the sample tap.
3. Determine the CFT or CFV for each segment of pipe using Table 1 (time) or Table 2 (volume), respectively, as shown in the example below. Round the pipe length to the nearest value. For I.D. less than 3/8 inch, use the CFTs for 3/8 inch. Note: actual I.D. may vary depending on pipe material and degree of corrosion inside the pipe.

   100' of 3/4" I.D. line ➔ 1.1 minutes ➔ 2.3 Gallons
   52' of ½" I.D. line (round to 50') ➔ 0.3 minutes ➔ 0.5 Gallons
   Total CFT = 1.4 minutes × 2 (safety factor) = 2.8 minutes or 2.8 gallons x 2 (safety factor) = 5.6 gallons

4. If applicable, remove aerators from sample tap before sampling.
5. If flow measurement is used then turn on the tap and start a timer to ensure a proper flush time. Then check the flow rate. If it is significantly different than 2 gpm, adjust the CFT in Table 1 using the following equation, as shown with the example below.

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

Example: 5 gpm flow rate ➔ $CFT_{5\ gpm} = 2.8\ minutes \times \frac{2\ gpm}{5\ gpm} = 1.1\ minutes$

6. If volume measurement is used, flush the line for the proper amount of volume using a marked bucket or other appropriate measuring device.

Equipment Needed to Determine CFT/CFV

- Measuring device (i.e., cup, bucket, meter setup) – to measure sample volume; 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/Distance Wheel – to measure length of line

Table 1: Calculated Flush Times (minutes) at 2 gpm

Length (feet)	Internal Diameter (inches)								
	3/8	½	¾	1	1 ½	2	2 ½	3	4
1	0.00	0.01	0.01	0.02	0.05	0.1	0.1	0.2	0.3
10	0.03	0.05	0.1	0.2	0.5	0.8	1.3	1.8	3.3
20	0.1	0.1	0.2	0.4	0.9	1.6	2.6	3.7	6.5
30	0.1	0.2	0.3	0.6	1.4	2.4	3.8	5.5	9.8
40	0.1	0.2	0.5	0.8	1.8	3.3	5.1	7.3	13.1
50	0.1	0.3	0.6	1.0	2.3	4.1	6.4	9.2	16.3
60	0.2	0.3	0.7	1.2	2.8	4.9	7.7	11.0	19.6
70	0.2	0.4	0.8	1.4	3.2	5.7	8.9	12.9	22.8
80	0.2	0.4	0.9	1.6	3.7	6.5	10.2	14.7	26.1
90	0.3	0.5	1.0	1.8	4.1	7.3	11.5	16.5	29.4
100	0.3	0.5	1.1	2.0	4.6	8.2	12.8	18.4	32.6

Table 2: Calculated Flush Volume (Gallons)

Length (feet)	Internal Diameter (inches)								
	3/8	½	¾	1	1 ½	2	2 ½	3	4
1	0.01	0.01	0.02	0.04	0.09	0.16	0.3	0.4	0.7
10	0.06	0.10	0.2	0.4	0.9	1.6	2.5	3.7	6.5
20	0.11	0.2	0.5	0.8	1.8	3.3	5.1	7.3	13.1
30	0.2	0.3	0.7	1.2	2.8	4.9	7.6	11.0	19.6
40	0.2	0.4	0.9	1.6	3.7	6.5	10.2	14.7	26.1
50	0.3	0.5	1.1	2.0	4.6	8.2	12.7	18.4	32.6
60	0.3	0.6	1.4	2.4	5.5	9.8	15.3	22.0	39.2
70	0.4	0.7	1.6	2.9	6.4	11.4	17.8	25.7	45.7
80	0.5	0.8	1.8	3.3	7.3	13.1	20.4	29.4	52.2
90	0.5	0.9	2.1	3.7	8.3	14.7	22.9	33.0	58.7
100	0.6	1.0	2.3	4.1	9.2	16.3	25.5	36.7	65.3

Note: some water systems and state primacy agencies (not ADEM) have applied a **5 minute flush time** before sample collection. This may be excessive at some locations, but appropriate at others (e.g., if the service line I.D. is ¾", the total length of line between distribution main and sample tap is about 250', and the tap flow rate is 2 gpm) such as a residence, which typically has a ¾" meter. This approach should not be applied at a business or a larger building, which typically have larger meters.