Domestic Water Systems Flushing Procedure:

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This document is Part 2 of a discussion on a procedure for how to flush building water systems after a building has been unoccupied for a long period of time.

Building Address: _____ Flushing Date: _____

Name of Persons Conducting the Flushing Operation:

_____

Flushing personnel should wear at least an "N-95 respirator mask" and Personal Protective Equipment (PPE) during flushing operations. When performing a flushing operation, complete the following flushing procedure in the following sequence:

1. Determine how long the building has been significantly unoccupied or shutdown.
   - □ Building has been shutdown/significantly unoccupied for _____ Days. Date of shut-down: M___/D___/Y_____

2. Determine the water utility's water treatment chemical type. For chlorine, there should be a minimum 1 part per million (ppm) free chlorine at the building service entrance, and 0.5ppm of free chlorine at the remote fixtures. If the water is not in this range contact your water utility provider. They may need to flush the mains coming to your property. For buildings with other water treatment chemicals in the utility water, consult with a professional for recommended minimum water treatment chemical levels entering the building.
   - □ Utility's Water Treatment Chemical Type? _____

3. Collect a water sample of first draw water and test the water treatment chemical residuals at the water service entrance. There are many locations within the water service entrance that can be used, however, just choose one location where a sample can be drawn for testing. This pre-flush test will serve as a baseline to compare pre-flush water quality with post-flush water quality. Record the information in the space below:

- □ Sample Location: _____; Free Chlorine Residual: _____ppm; Test By: _____; Time: _____ am/pm
- □ Sample Location: _____; Legionella Test[3]: _____ #/ml; Test By: _____; Time: _____ am/pm
- □ If the pre-flush water quality test indicates any water discoloration, odor, or other unusual characteristics, note them below:
- □ Notes: _____

Note 1. - 4 to 14 days unoccupied: Test & Flush. Note the chlorine residuals prior to flushing and signs of water degradation, (color, odor, etc.) If chlorine levels are below 0.5 ppm Disinfect and flush within 4 days of significantly reoccupying the building.

Note 2. - For more than 14 days unoccupied, Flush and disinfect within 4 days of significantly reoccupying the building if pre-flush testing shows less than 0.5 ppm of chlorine residual.

Note 3. - For more than 28 days unoccupied. Consider conducting a test of the chlorine or water treatment chemical residuals and provide Legionella test on pre-flush water and post-flush water. Consult a professional about which type of Legionella test is appropriate.

4. Collect a water sample of first draw water and test the water treatment chemical residuals in at least five (5) remote locations within the building. These locations should be documented. These pre-flush tests will serve as a baseline to compare pre-flush water quality with post-flush water quality. Record the information in the space below:

   - □ Loc. #1 _____; Free Chlorine Residual: _____ ppm; Test By: _____; Time: _____ am/pm
   - □ Loc. #1 _____; Legionella Test[1]: _____ #/ml; Test By: _____; Time: _____ am/pm
   - □ Loc. #2 _____; Free Chlorine Residual: _____ ppm; Test By: _____; Time: _____ am/pm
   - □ Loc. #2 _____; Legionella Test[1]: _____ #/ml; Test By: _____; Time: _____ am/pm
   - □ Loc. #3 _____; Free Chlorine Residual: _____ ppm; Test By: _____; Time: _____ am/pm
   - □ Loc. #3 _____; Legionella Test[1]: _____ #/ml; Test By: _____; Time: _____ am/pm
   - □ Loc. #4 _____; Free Chlorine Residual: _____ ppm; Test By: _____; Time: _____ am/pm
   - □ Loc. #4 _____; Legionella Test[1]: _____ #/ml; Test By: _____; Time: _____ am/pm
   - □ Loc. #5 _____; Free Chlorine Residual: _____ ppm; Test By: _____; Time: _____ am/pm
   - □ Loc. #5 _____; Legionella Test[1]: _____ #/ml; Test By: _____; Time: _____ am/pm

   Note 1. *– Conduct a Legionella test if the building has been significantly unoccupied for more than 28 days. Consult a professional for which type of Legionella test is appropriate.*

   If the pre-flush water quality test indicates any water discoloration, odor, or other unusual characteristics, note them below:
   Notes: _____

5. If the pre-flush water quality tests show the water quality is good, then no service pipe flushing is needed.

6. If the pre-flush water quality test indicates any water discoloration, odor, other unusual characteristics, or a lack of sufficient free chlorine residual, perform a full velocity flush of 3 feet per second through the building water service pipe. Record the information on the form provided below.

7. Determine the minimum volume of water to be flushed through the service pipe at 3 feet per second velocity, as follows:

   a. Determine the pipe size and length: Record the information in the space below:

      - □ Service pipe size: _____ , volume gallons per linear foot.
      - □ Service pipe length: _____

   b. Determine the volume of water in the building service pipe based upon its size and length, See Table 1, below.

   c. Multiply the volume of water in the building service pipe by a factor of 2 in order to determine the minimum volume of water to be flushed through the service pipe.

      - □ Service pipe volume (from Table 1): _____ (linear feet of service pipe x volume per foot, from #3 above)
      - □ Service pipe volume (from Table 1) x 2: _____ Note 1

   .

8. Using Table 2, determine the quantity of fixtures required to be flowed simultaneously in order to have a velocity of 3 feet per second in the service pipe, or determine the flow in gallons per minute (gpm) required to have a velocity of 3 feet per second in the service pipe. Flow should be from hose valves or fixtures near the service entrance. (Note: A minimum flow velocity of 3 feet per second is required to scour bio-film and sediment from the service pipe.) Record the information on the form provided below.

9. Minimum time to flush the water service pipe two (2) times the volume of water in the service pipe can be determined with the following calculation:

    - Flow velocity @ 3 Feet per second x length of the pipe = Min. flushing time. Example:
        1) Building water service pipe = 6 inches
        2) Length of service pipe from water main to hospital building = 1,500 feet.
        3) Minimum flow velocity = 3 feet per second
        4) 1500 feet / 3 fps = 500 seconds (500 secs divided by 60 sec per minute = 8.33 minutes x 2 (2 times the volume of the pipe) = about 17 minutes of flushing with 60 fixtures continuously flowing simultaneously or 120 gpm per table 2)
        5) The process is similar for flushing large building water distribution branches.

10. Flush the building water service pipe and all fixture branch pipes within 4 days of reopening. Perform a disinfection procedure if determined necessary based on the water treatment chemical residuals and the time the building has been unoccupied.

11. If a disinfection residual is not detected, after 30 minutes of flushing the building service pipe, stop flushing and contact the water utility. Ask them about options for flushing the water mains near the building. If they are overwhelmed, ask them if the fire department could help flush the water mains through nearby fire hydrants to bring chlorinated water closer to the building. If the building is in a cluster of buildings or in an area with many unoccupied buildings there may be a logical place to flush a hydrant near the end of the street that will flush fresh chlorinated water by all buildings in the area.

12. After a disinfectant residual is detected on the water service entrance, and before continuing to flush the building branch piping, determine which fixtures to open as indicated on the last column of Table 2 “Min. # of remote fixtures flowing during entire flush”. Flow some fixtures that are the farthest away from the building water service and with at least one flowing on the end of each building branch main of the building’s water distribution piping branches and let the cold (and hot) water run continuously until a disinfectant concentration is detected close to, or equal to the chlorine residuals measured in the building service connection. Typically, the residuals in the building will be less than the service entrance unless there is a supplementary water treatment system. A branch main is defined as a main distribution pipe, typically greater than ¾” diameter, which supplies other branch pipes and fixture branch pipes)

13. Flush Valves: Flush all sinks and lavatories first. Next, flush showers and tank type water closets. Lastly, flush fixtures with flushometer valves such as flush valve type water closets and urinals. Fixtures with flushometer valves can become clogged with debris and not flush properly, (allow water to continuously run) if they are flushed first and debris gets into the metering orifices. If flush valves do not perform properly and run-on, shut off water and remove diaphragm and clean the orifice. When done flushing, remove faucet strainers and shower heads and clean or replace them.

14. Flush all remaining fixtures, tanks, and appliances connected to the potable water system, including exterior outlets. Flow water from both the hot and cold water systems. The following flushing procedure should be used, based on each fixture type:
    a. Toilets and urinals shall be flushed at least 5 times each for 1.6 gallons per flush (gpf) fixtures or a number of times sufficient to adequately flush the branch piping to the fixture.

b. All other fixtures shall be flushed for a minimum of 3 minutes each, both hot and cold water with flows of 2 gpm.
c. Any water storage or hot water tanks should be flushed at a rate to flow at least 2 times the volume of the tank.
d. Hydro-pneumatic and thermal expansion tanks should have the water pressure relieved from them so that they totally discharge all water within the tank.
e. Infra-red faucets shall be operated for a consecutive period of time equal to 20 cycles for every 10 feet of ¾ inch branch piping.
f. For ice machines: empty, clean and disinfect waterways and the ice bin. Remove water supply pipe from filter and flush for 3 minutes or until adequate chlorine residuals are present up to filter connection. Flush and disinfect or replace all flexible piping downstream of the charcoal filter. Check for adequate ventilation around the refrigeration machine to lower the temperature exposure to the water supply pipe and minimize bacteria growth. Flush and disinfect the filter cartridge containers and replace the filter cartridges. Wash down (melt) first two batches of ice after cleaning procedure and rinse ice bin clean before putting ice machine back in service.
g. _____
h. _____

Service Pipe Flushing Record Sheet

Date: _____ By: _____

Address: Building: Floor:

Wtr Serv. Entrance Rm. #	Util. Chem. Type	Start time	Start Temp F	End time	End Temp F	Flow gpm or gpf	PPM chlorine or other chem. 1st draw / end	Notes:
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Fixture Branch, Flushing Record Sheet

Date: ________________ By: ____________

Address:

Building: Floor:

Room #	Fixture Type/ID	Start time	Start Temp F	End time	End Temp F	Flow gpm or gpf	PPM chlorine or other chem. 1st draw / end	Notes:
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Table – 1 Volume of Water In Each Linear Foot of Piping	
Pipe Size (inside diameter inches)	***Water Volume* (gallons/lin. ft)**
1/4	0.003
3/8	0.006
1/2	0.010
3/4	0.023
1	0.041
1 1/4	0.064
1 1/2	0.092
2	0.163
2 1/2	0.255
3	0.367
4	0.653
5	1.02
6	1.47
8	2-61
10	4.08
12	5.88
15	9.18
18	13.2

Table 2 - Water System Flushing for 3 Feet Per Second (FPS) Scouring Velocity			
Bldg. water service pipe size	**Approx. # of fix's flowing at same time[A]**	**Minimum flow in GPM[B] during test for 3 FPS vel.[C]**	**Min. # of remote fixtures flowing during entire flush**
½ inch	2	2.5	1
¾ inch	3	5	1
1 inch	5	9	1
1-1/4 inch	7	13	2
1-1/2 inch	9	18	2
2 inch	14	28	3
2-1/2 inch	21	42	4
3 inch	31	62	5
4 inch	60	120	8
5 inch (not standard size)	90	180	12
6 inch	125	250	16
8 inch	166	332	21
10 inch	206	412	25
12 inch	248	495	30

Notes:

A. Based upon 2 gallons per minute flowing per fixture. Adjust, as required, if fixture flow rates are different. (See Table 3)

B. Verify drain capacities at these flow rates. Limit flows to drain capacity to avoid flooding. (Flowing the supply pipe at 3 fps could cause drain issues with some drains.)

C. Flow velocity of 3 feet per second is determined on Chart A.

Table 3 - Fixture Typical Flow Rates (to drain 20 feet of branch pipe)		
Fixture	**Maximum flow rate**	**Time or # Flushes**
Water Closet, Tank-Type	Tank Fill rate = 1.5 gpm+- (1.6 gal's. per flush gpf)	5 Flushes
Water Closet, Tank-Type	Tank Fill rate = 1.5 gpm+- (1.28 gpf)	6 Flushes
Water Closet, Flush Valve (Larger Supply Pipes)	Flush rate = 35 gpm for 3 seconds+- (1.6 gpf)	10 Flushes
Water Closet, Flush Valve	Flush rate = 35 gpm for 2.2 seconds+- (1.28 gpf)	12 Flushes
Water Closet, Pressure Assist	Tank Fill rate = 1.5 gpm (1.28 gpf)	6 Flushes
Urinal Flush Valve	Flush rate = 8 gpm for 4 seconds+- (0.5 gpf)	10 Flushes
Urinal Flush Valve	Flush rate = 8 gpm for 1 seconds+- (0.1 gpf)	40 Flushes
Older Tank-Type Water Closets	Fill rate 1980-1992 = 2 gpm+- (3.5 to 5 gpf)	7 Flushes
Older Tank-Type Water Closets	Fill rate prior to 1980 = 2 gpm+- (5 to 7 gpf)	4 Flushes
Lavatory – Infra-red Faucet	0.5 gpm @ 0.25 gal/cycle max. w/ 10 sec/cyc = 0.041gpc	40 cycles (to flush 20 ft of ¾")
Lavatory/Sink	0.5 gpm	8 mins
Lavatory/Sink	1.0 gpm	4 mins
Lavatory/Sink	1.5 gpm	3 mins
Lavatory/Sink	2.0 gpm	3 mins
Lavatory/Sink	2.2 gpm	3 mins
Shower	2.5 gpm	10 mins
Shower	2.0 gpm	10 mins
Shower	1.5 gpm	15 mins
Shower	1.0 gpm	20 mins
Shower	0.5 gpm	40 mins
Hose Bibb	10 gpm 1-inch supply	Note 1
Hose Bibb	5.0 gpm 3/4-inch supply	Note 1
Hose Bibb	3.0 gpm 1/2-inch supply	Note 1
Bathtub/Whirlpool Bathtub	5.0 gpm 3/4-inch supply	Note 1
Bathtub/Whirlpool Bathtub	3.0 gpm 1/2-inch supply	Note 1
Other fixture _____	_____ gpm	Note 1
Other fixture _____	_____ gpm	Note 1
Other fixture _____	_____ gpm	Note 1

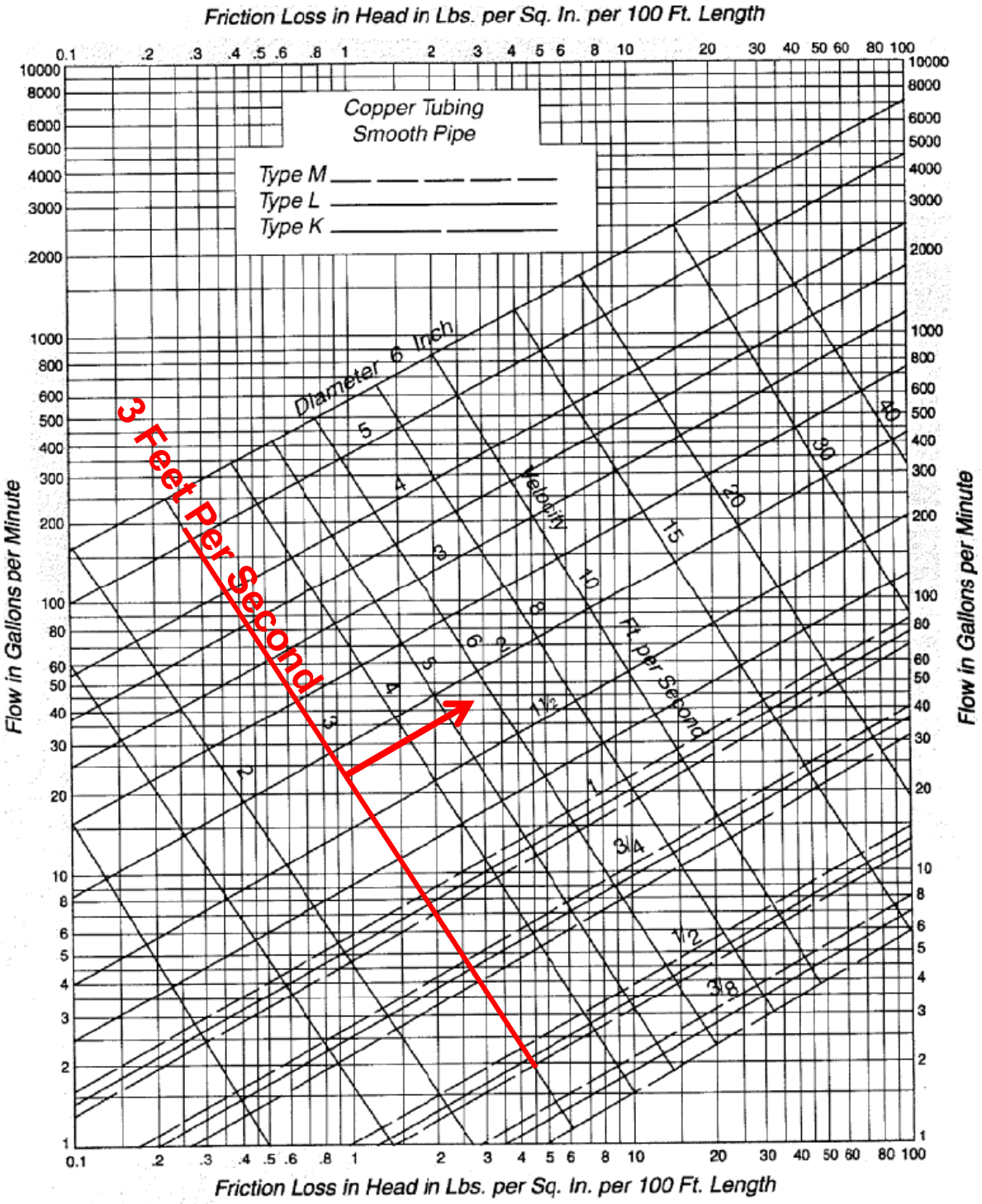
Notes:

1. Refer to Table 1 for water volume in branch to be flushed based on length. Multiply developed length x 2 for minimum volume to be flushed.

Table A – Effects of Temperature on Legionella Bacteria *By: Ron George, CPD*	
Temperature	**Result**
Below 68F	Legionella survives, but will not reproduce
68 F	Legionella will double its population in 8 days
77 F	Legionella will double its population in 3 days
68 F to 122 F	Legionella bacteria growth temperature range[3]
95 F to 115 F	Ideal Legionella bacteria growth temperature range
Above 122F & Below 131 F	Legionella bacteria can survive but will not grow or multiply[2]
131 F	Legionella bacteria dies in 5 to 6 hours[2]
140 F	Legionella bacteria dies in 32 minutes[2]
151 F	Legionella bacteria dies in 2 minutes[2]
158 F +	Legionella bacteria dies instantly (Disinfection temperature)[2]

Notes:

1. This is based on laboratory tests, field conditions may vary due to differences in water quality, insulating properties of biofilm/scale
2. Some types of water heaters are not capable of heating to non-growth or disinfection temperatures.
3. The coolest point in the hot water system (Hot water return pipe) should be a couple of degrees above the highest growth temperature.



Source: Page 31, PDI-WH201-2010 Water Hammer Arrestors.

Chart A – Water Pipe Size, Velocity, Flow in GPM and Frition Loss per 100 feet