Address: 303 N. Monroe St., Monroe, MI 48162
Mailing Address: P.O. Box 47, Newport, MI 48166

**Ronald L George, CPD, President**

**Plumb-Tech Design & Consulting Services, LLC**
Ph: (734) 322-0225 Cell: (734) 755-1908
*E-mail: Ron@Plumb-TechLLC.com* *Website: www.Plumb-TechLLC.com*
*Plumbing, Piping, Fire Protection, & HVAC System Design Services, Forensic Investigations of Mechanical System Failures, Litigation Support, Code and Standard Consulting, Technical Writing, Training Seminars*

# PRESS RELEASE

Part 1 of 2

May 6, 2020

## Flushing Bacteria from Stagnant Building Water Piping

By: Ron George, CPD

Below is a recommended flushing procedure for building owners, property managers, water utilities, health officials, code officials, service contractors, engineers, insurance companies, and interested parties to refer to when recommending or performing flushing operations for building water systems before re-opening buildings for occupancy after a long shut-down.

With the recent Coronavirus events causing many stay-at-home orders and extended vacancy of offices and workplaces, there is a looming, serious issue associated with stagnant water or aging water in the plumbing piping systems of buildings that have not been occupied for long periods of time. Bacteria will grow and flourish in the biofilm of the plumbing system that have been sitting stagnant with ambient temperature or warm water where the water treatment chemicals have been given time to dissipate to levels that will not control bacterial growth. Studies have shown water treatment chemicals dissipate over time, and there are several factors that affect the rate of dissipation, such as pipe material, temperature, and organic contaminants in the water. After the chlorine dissipates, bacteria can grow to high numbers. When Legionella bacteria are aerosolized in water from showers and other fixtures, they can be inhaled into the lungs, causing Legionellosis or Legionnaires' disease. Therefore, it is important to flush stagnant pipes containing bacteria-laden water before re-occupying the buildings that have been vacant for long periods of time.

There are AWWA standards for flushing and disinfecting public water utility mains, however, there are no standards for flushing and disinfecting plumbing systems within buildings. The ASHRAE 188 Standard establishes criteria for establishing a water management team. A water management team should perform a risk assessment of the building water systems and develop a water management plan customized for the building. The ASHRAE 188 Standard recommends flushing, but it does not go into details of how the flushing procedure should be done. For emergency disinfection, there are two methods. Chemical and Thermal. Thermal disinfection only disinfects the hot water system and can only disinfect the system if the water heater can reach a disinfecting temperature. Many water heaters are not capable of reaching temperatures high enough to disinfect the entire hot water distribution system when you include the heat loss in the circulated hot water distribution system.

Chemical disinfection requires a professional to administer the disinfectant at levels that will disinfect without getting so high as to be corrosive to the piping system. Many metallic piping systems and a some types of plastic piping systems can be degraded by excessive chlorine exposure. Chemical disinfection typically requires the building to be licensed as a public water treatment operator and in many cases the State may require licensing and/or certifications for persons performing the disinfection work.

Under normal operating conditions storage type water heaters should be maintained at a temperature high enough to kill legionella bacteria and then utilize a temperature actuated mixing valve Conforming to the standards in the code, (ASSE 1017 or CSA B125.3) to stabilize the hot water delivery temperature. Some organizations have recommended storing hot water in excess of 135 F - 140 F or higher temperatures as needed in the tank to offset heat loss and maintain a minimum hot water temperature a couple of degrees above the Legionella growth temperature of 122 Fahrenheit at the lowest temperature point in the system. Some engineers and guidelines recommend a safety factor or buffer of a couple of degrees and they recommend a minimum temperature of 124 F at the lowest temperature point in the system In systems with circulating pumps, this would require a temperature gauge on the hot water return pipe connection near where it returns to the water heater to assure the entire hot water distribution system is above the Legionella growth temperature. The temperature gauge on the hot water return pipe should be located just before the tee where the hot water return splits to direct the return hot water to the cold water connection of the water heater and the cold water inlet of the mixing valve. This is the lowest temperature point in the hot water system. (See *"Table A - Effects of Temperature on Legionella Bacteria"*.)

**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.

Before re-occupying a building that has been unoccupied for more than 4 days, it is recommended to flush stagnant water from the piping system before opening the building to occupants. To minimize the chances of transmission of Legionella bacteria and other microorganisms to humans, flushing water from the plumbing fixtures is the easiest, quickest, and cheapest way to prepare for occupants to return to the building.

The water utility has a duty to deliver safe drinking water to the building service meter according to the safe drinking water act. However, the utilities are allowed fall below the minimum level of quality in the safe drinking water act for three, consecutive 6-month reporting periods while they try to make corrective actions before they must notify the public of a water quality issue. There have recently been efforts to revise these reporting requirements and adjust the list of contaminants in drinking water and require trigger levels when the water utilities must notify their customers of a boil water advisory or other issue. The responsibility for building water safety is the responsibility of the building owner. The drinking water provider has no responsibility for water quality on the building side of the water meter. A water utility should strive to deliver quality water, but we know that the water utilities cannot guarantee safe drinking water because there are often water main breaks, construction, fire events and other disruptions of water main flows that cause turbid water and high bacteria events. For this reason, the building owner has a duty and responsibility to monitor the water quality coming into their building. Therefore, having a water management plan or water safety plan in place to have a plan for building operators to monitor and react to incoming water quality issues is important.

In the last 3 decades, we have been in a water and energy conservation mode. Water flows have been reduced to levels that are less than 20 percent of flows prior to 1992. The flow velocity in water mains have been reduced to the point where water treatment chemical residuals often dissipate to levels that will not control bacterial growth in the water mains near the ends of larger water distribution systems. The lack of chlorine residuals at the end of distributions systems has caused some water utilities to switch to other water treatment chemicals. When conditions are right, chlorine can dissipate to levels that will not control Legionella bacteria growth in about 5 days.

For these reasons, some utilities have switched to new water treatment chemicals that have caused degradation of gaskets, o-rings, and seals in plumbing systems. The new chemicals also had other issues, when they oxidize, they have a waste by-product that is reported to be a food source for some micro-organisms, like Nontuberculous Mycobacteria (NTM) that are another type of deadly bacteria. Building owners must monitor the incoming water and adjust the water quality as needed by using supplementary water treatment systems. When a building owner is considering a supplementary treatment system, they should consult with a professional to determine if they need licensing, certification and any filters.

Every fixture in the building should be flushed in accordance with these guidelines or until the water treatment chemical residuals reach an acceptable level. If flushing does not improve water quality, contact the water utility and consider contacting a water treatment professional. Following these procedures should prevent thousands of workers from getting sick and dying from Legionnaires disease and other types of waterborne bacteria and illnesses associated with stagnant water.

The recommended flushing procedure attached should be used by building owners, property managers, water utilities, health officials, code officials, service contractors, engineers, insurance companies, and interested parties to refer to when recommending or performing flushing operations on build water systems before re-opening buildings for occupancy after a long shut-down to reduce the risk of illness and death.

# Domestic Water Systems Flushing Procedure:

Date: 5-6-20

*By: Ron George, CPD*

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

*For updates or comments, reply to: Ron George P.O. Box 47 47, Newport, MI 48166, President, Plumb-Tech Design & Consulting Services, LLC, Phone: (734) 755-1908*

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 shut down or 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 a lack of sufficient free chlorine residual, any water discoloration, odor, other unusual characteristics, 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. (From Table 1)
      - ☐ Service pipe length: _________ From water main to meter or building service entrance.

   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 #7a above)
      - ☐ Service pipe volume (from Table 1) x 2: _________

.

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. (<u>Note</u>: A minimum flow velocity of 3 feet per second is required to scour biofilm 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:

   a. 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 (See 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 the 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 consecutive periods 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. Other fixtures or Equip. ________________________________________________
h. Other fixtures or Equip. ________________________________________________
i. Other fixtures or Equip. ________________________________________________
j. Other fixtures or Equip. ________________________________________________

| **Service Pipe Flushing Record Sheet**<br>Address: | | | | | | | Date: ________________ | By: ____________<br>Building: Floor: |
|---|---|---|---|---|---|---|---|---|
| **Wtr Serv. Entrance Rm. #** | **Date** | **Start time** | **Start Temp F** | **End time** | **End Temp F** | **Flow gpm or gpf** | **PPM chlorine or other chem. 1st draw / end** | **Notes:** |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |

# 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: |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |
| | | | | | | | / | |

| 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 | 130 | 260 | 16 |
| 8 inch | 235 | 470 | 21 |
| 10 inch | 365 | 730 | 25 |
| 12 inch | 530 | 1,060 | 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. Consider adding fire hose valves for flushing where needed.)
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 |
| | | |

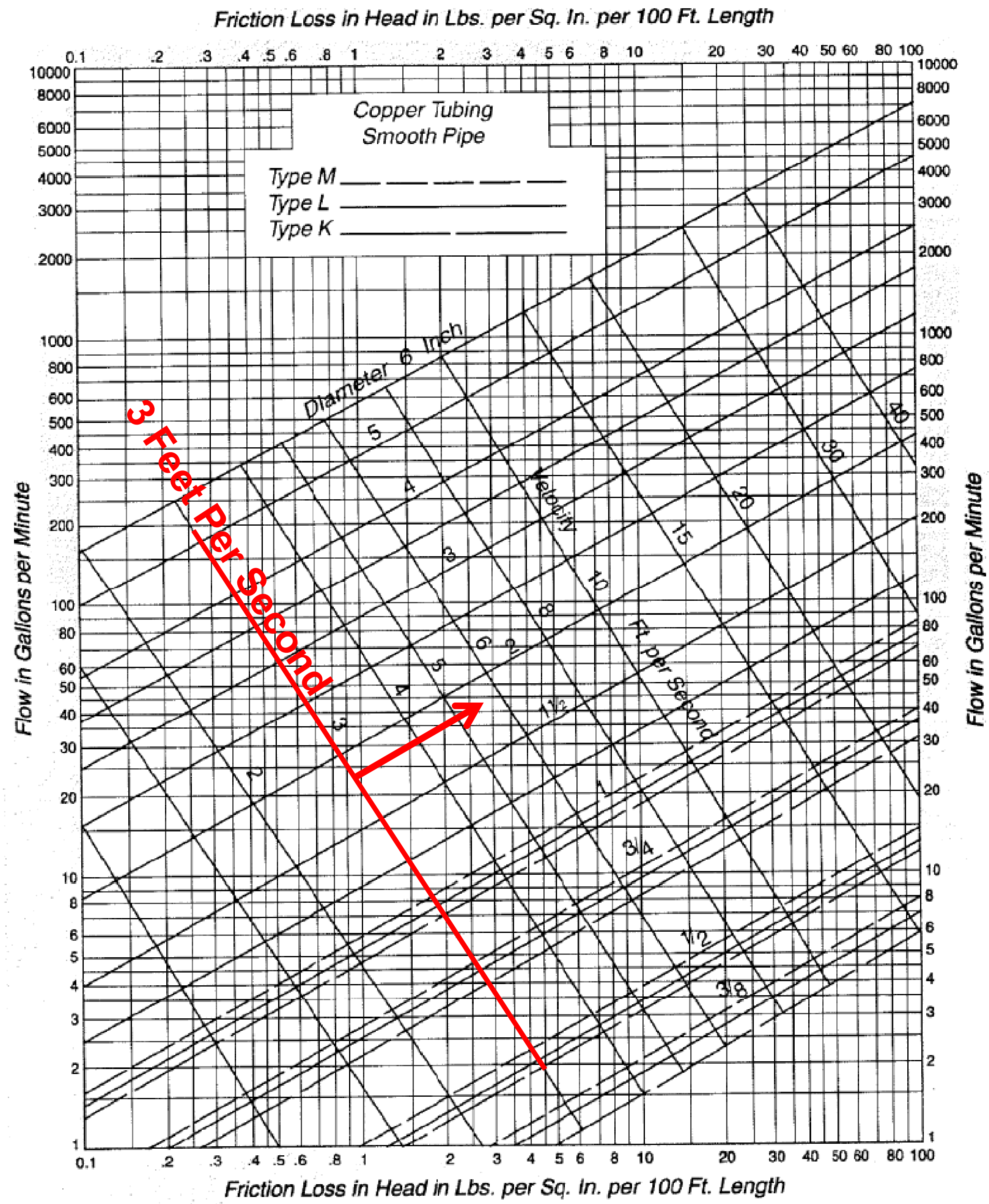
**Notes:**

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.

**<u>Chart A – Copper Water Pipe Size, Velocity, Flow in GPM and Friction Loss per 100 feet</u>**

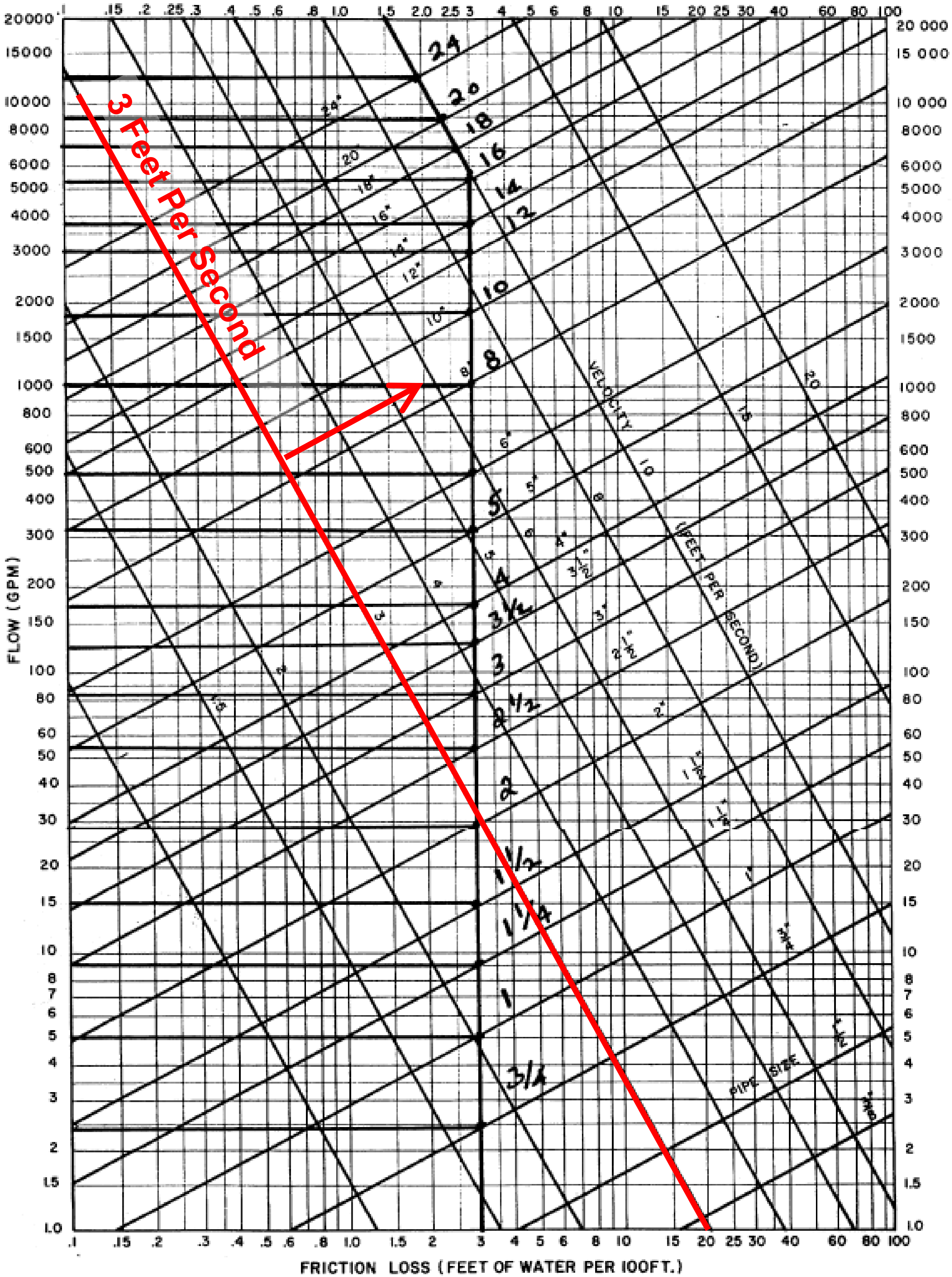



**Chart B – Ductile Iron Water Pipe up to 24", Velocity, Flow in GPM and Friction Loss/100'**