

Water Resources Design Task

1.101 Fall 2006

Background

In certain regions, well water tends to be acidic. In eastern Massachusetts, for example, the pH of precipitation can be as low as 4 or even lower, and in the absence of enough neutralization by soils the resulting groundwater will also be acidic. It is also possible for local geologic conditions to contribute acidity to groundwater, as when organic acids are produced in wetlands.

One result is that water drawn from wells and springs can be acidic enough to dissolve metals from distribution pipes. If the distribution pipes are of lead, or—as is much more common nowadays—are of copper with connections soldered together with solder containing lead, significant amounts of lead can be dissolved into the drinking water that passes through the pipes. Although quantitative measures of the dissolution of lead require chemical analysis of the water, evidence for the corrosion of piping may be revealed by the presence of blue-green stains on plumbing fixtures beneath water taps or shower heads. The color is due to copper in the water; where copper is being dissolved, it is a good bet that lead from lead-based solder is also. [See MWRA, *A Report on What's New about your Drinking Water*, p. 5, Stellar posted as *MWRA Annual Report 05*].

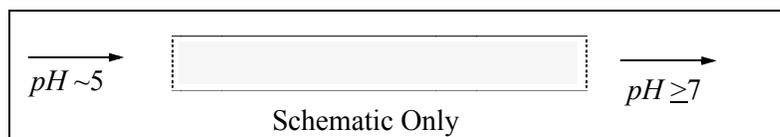
One way to limit the dissolution of metals from the piping is to eliminate the metals from the piping system. In fact, in Massachusetts it is now required that copper pipes in new houses be soldered with lead-free solder. This, however, is of no help to the vast majority of older homes that have lead-based solder. In these cases, raising the pH of the water to make it less corrosive can be a way to mitigate the problem.

Design Task

Your job is to design, fabricate, assemble and test a system, (a column) that neutralizes the acidity and hence much of the corrosivity of water in a residential water system. Market surveys reveal that residents notice the effects of acidity when their water source has a pH of 5 or less. These same surveys also show that family size clusters in the range 3 to 5 and the typical residence is a single family, three bedroom, two bath unit. Your boss has set out the following requirements.

Requirements

- pH of the water delivered at the tap is to be 7 or higher.
- Decrease in flow rate at the tap (or shower head) is to be tolerable, if not go unnoticed.
- Pressure drop is not to exceed 15% of the supply pressure.
- System should not leak
- Space needs should not be excessive.



Other Considerations

- Cost
- Service & Maintenance - Time to recharge.
- Transient Conditions

Resources

A listing of available component resources - pipes, valves, couplings, pressure gages, and the like - will be provided in lab. Ground calcium carbonate of three partial size distributions will be provided.

Test Plan

Your system will be tested to prove its worth. Water, with a *pH* approximately equal to 5 and at a pressure in the range 40 to 60 psi, will be provided as a supply. The figures on the next page show the interface geometry.

You will measure the following variables in steady flow conditions:

- the pressure drop in psi
- the flow rate in gallons/minute
- the pH delivered

Further details of the recommended test procedure will be provided as needed.

Report

Your effort is a group effort. But each individual is responsible for documenting their contribution in their lab notebook. You are to produce a single, *group report*. It's contents should include:

- Summary of design task as given with requirements.
- A drawing of suitable detail such that one responsible for fabrication of parts - e.g., someone familiar with your work like Stephen Rudolph - could do so without coming to you with too many questions.
- A parts list - including specification of porous material.
- Performance measures - pressure drop, flow rate, *pH* delivered.
- Reflections on design process & on your product.
- An Appendix with an analysis justifying your choice of design parameters built upon the results of your experimental determination of residence time and flow conductivity.(NOTE: THIS APPENDIX IS TO BE PREPARED FOR DISTRIBUTION AT YOUR FIRST DESIGN REVIEW).

System Interface:

