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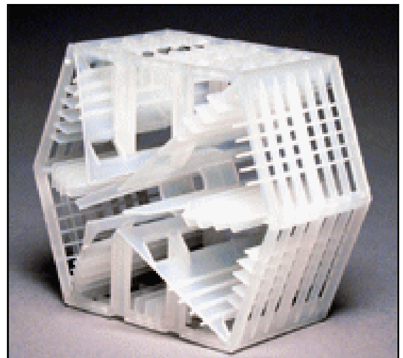
CO_2 Degasifiers / Drinking Water Corrosion Control
Air Stripper Tower Design for EPA Lead and Copper Rule Compliance

Background

After the phase-out of leaded gasoline and the ban on lead-based pigments in house paint, concern has focused on the risk of lead exposure from drinking water due to corrosion of old plumbing containing lead pipe or solder. To reduce this public health risk, the EPA's Lead and Copper Rule now requires many drinking water systems to deliver water at higher pH so that it will be less corrosive. The pH can be raised using less caustic or lime—and adding less dissolved solids to the water—if most of the CO_2 in the water is first removed by air stripping.



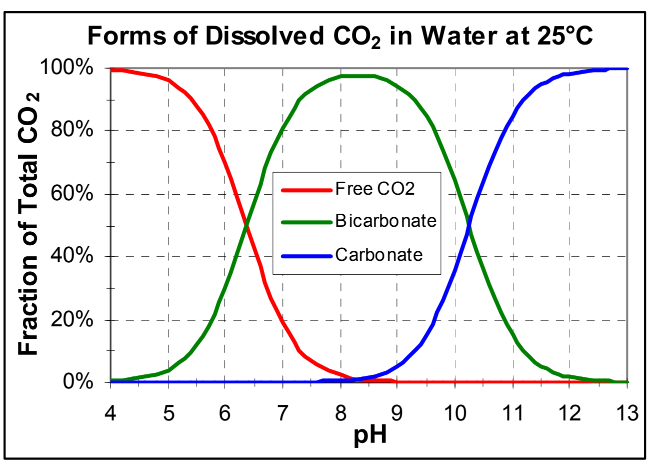
3.5" LANPAC®

Packed-tower air strippers—also called "degasifiers"—are an inexpensive way of removing dissolved CO_2. The raw water is pumped over a bed of porous packing media while fresh air is blown upward through it. Dissolved CO_2 is transferred from the water to the air, and the pH rises in the process. The patented design of LANPAC® serves to maximize the efficiency of air-water contact, so degasifiers packed with LANPAC® can be more compact.

However, there are intrinsic limitations on CO_2 removal that cannot be overcome by advanced packing technology. Alkaline water tends to retain CO_2, so stripping becomes inefficient at pH >7.

Drinking Water Chemistry

Carbon dioxide in water is a weak acid. It is naturally present in rainwater, and is also formed by decay of vegetation in soils and by respiration of aquatic organisms. When rainwater percolates through the ground it dissolves alkaline minerals such as limestone. The water becomes "hard" and its pH and alkalinity increase as acidic CO_2 is converted to calcium bicarbonate and other salts.



When CO_2 dissolves in water, some of it forms carbonic acid, part of which dissociates into bicarbonate and carbonate ions.

$$CO_2 + H_2O \leftrightarrows H_2CO_3$$
$$H_2CO_3 \leftrightarrows H^+ + HCO_3^-$$
$$HCO_3^- \leftrightarrows H^+ + CO_3^=$$

Unreacted CO_2 and H_2CO_3 are collectively referred to as "free CO_2." Bicarbonate and carbonate ions are called "fixed CO_2." The sum of "free" and "fixed" CO_2 is the "total CO_2." The proportions of these different

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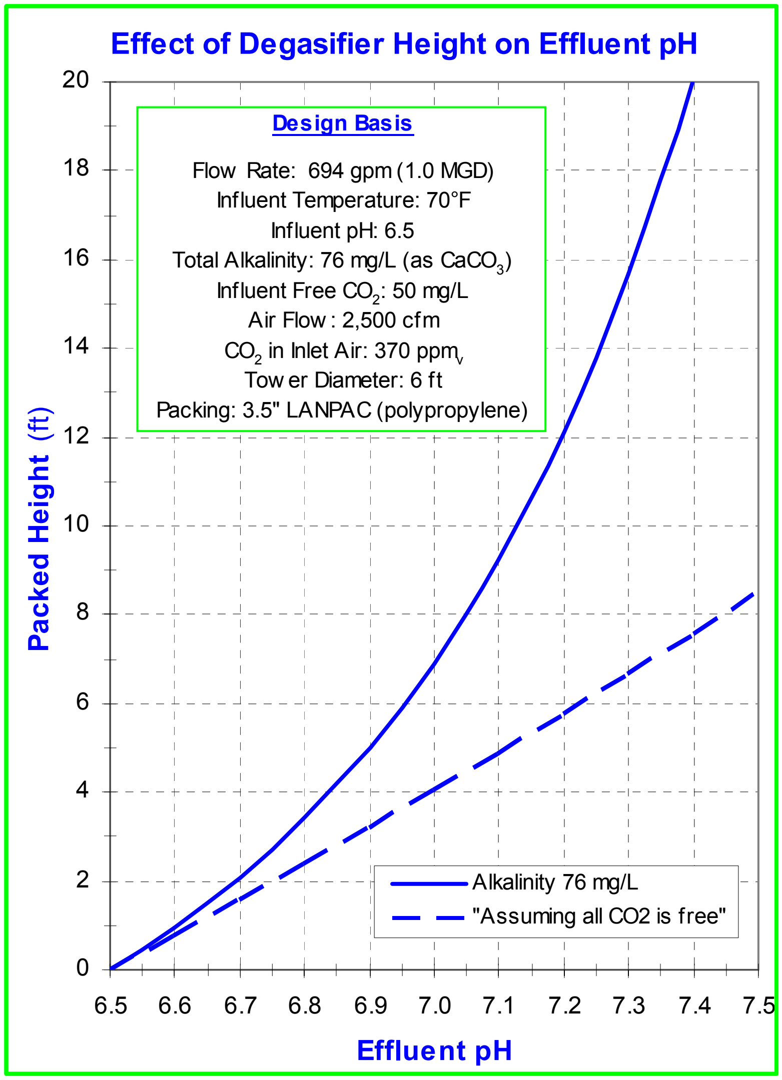
species depend on the pH of the water, as shown. In very acidic water (pH <5), excess hydrogen ion drives these equilibrium reactions to the left, so essentially all dissolved CO_2 is free CO_2, and stripping process design is relatively simple.

Tower Design Considerations



However, in drinking water pH adjustment, as CO_2 is stripped out and the pH rises, the scarcity of hydrogen ion shifts these equilibria toward fixed CO_2. The fraction of the total CO_2 that is in the strippable "free" form declines. Some of what *was* free CO_2 in the raw water is no longer free, and so CO_2 transfer to the air becomes slower in the lower part of the packed section.

As a result, more residence time (packed height) is needed for the same CO_2 removal. If the effluent pH exceeds 6, this will have a significant effect on air stripper sizing.

A common design error is to ignore this phenomenon, and size a tower for CO_2 removal assuming that all free CO_2 in the raw water will remain free, despite the rising pH. (That would really be true only for completely demineralized water with lower pH and zero alkalinity.) The magnitude of the error this can cause is shown by the example in the graph.

Tower designs based on such an optimistic assumption are usually offered without a performance warranty, for obvious reasons. In some cases, what at first appeared to be an economical stripping tower turned out to be an undersized unit that failed to perform as required, resulting in costly penalties or litigation for the system supplier, and chemical cost overruns for the drinking water system.

Buyer beware! See real project design: www.lantecp.com/technical/CO2degasifier_example.pdf

Complementary Design Service

Lantec Products provides free design consultation to users of is products, with performance warranties for degasifiers that are properly sized and operated.