By Frank A. Brigano & Andrew Lombardo

Filter Formula

Testing and developing a lead-reduction filter for gravity pitchers

In 2007, the NSF Intl. Drinking Water Treatment Unit Joint Committee revised the NSF/ANSI Standard 53 protocol for pH 8.5 lead reduction based on a substantial amount of research on particulate and colloidal lead. The research conducted by the NSF task group revealed a great deal of inconsistency in the amount of particulate lead formed from batch to batch and from laboratory to laboratory due to the precipitation of this element from the solution.

Differences in interpretation by laboratories in making the original pH 8.5 lead solution resulted in different amounts of particulate and colloidal lead formed that could cause the same filter to pass one time and fail another. After a great deal of research and round-robin testing, the task group proposed amending the pH 8.5 lead reduction protocol to define the particulate portion, which included a colloidal portion between 0.1 and 1.2 µm that would stay suspended in solution (Andrew 2008).

While this change in protocol did not pose much of a problem for pressurized filters such as carbon blocks because of their tight pore structures, it posed a significant hurdle for gravity flow pitcher filters. Most of the gravity filters on the market utilize combinations of granular-activated carbon and ion exchange resin to remove contaminants.

These filters have large interstitial voids, resulting in effective pore sizes that allow most particulate lead to pass directly through the filter (Palkon 2008). There are gravity filter products on the market that also make a microbial cyst claim, which would remove particles down to 3 µm, but the colloidal particles defined in the NSF/ANSI pH 8.5 lead protocol were still an order of magnitude smaller, meaning colloidal lead could pass through.

The change in protocol posed a particular problem for gravity pitcher filters. How could particulates as small as 100 nm be removed with the typical 3 to 4 in. (0.109 to 0.144 psi) of water pressure available to a gravity device? What filter pore size would be necessary to remove the colloidal portion of the solution?

Particulate Removal

To better understand how to remove colloidal lead with a gravity flow filter, KX Technologies LLC conducted tests to determine the pore size necessary to remove the particulate (colloidal) lead portion.

Samples of FACT media were made with pore sizes varying from 0.26 to 2.5 µm without any lead-scavenging media that would remove the soluble ionic lead. FACT filter samples were sent to a third-party laboratory that made challenge water according to the new NSF/ANSI Standard 53 pH 8.5 lead reduction protocol for evaluation. The failure point for the standard is 10 ppb in the effluent water, so the maximum pore size was determined by measuring the pore size that would remove the particulate portion below 10 ppb in the effluent (assuming the soluble portion could be removed with an ionic lead scavenger or ion exchange resin).

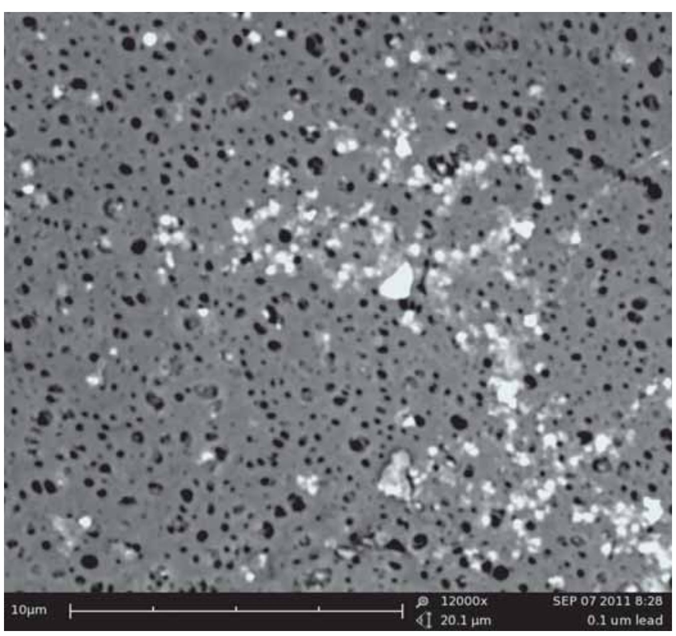
Figure 1 displays the results of this testing, which shows that the pore size needs to be less than 1.2 µm to adequately get below the 10-ppb effluent detailed in the protocol.

Reproducible Challenge Water

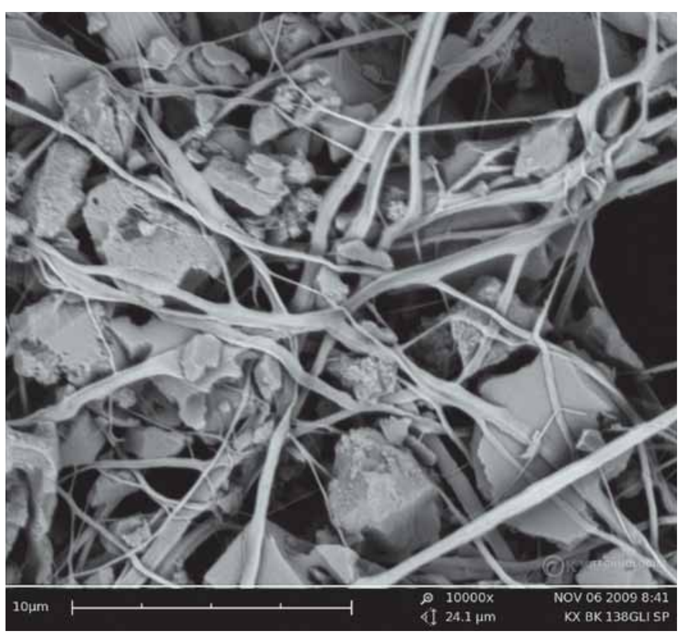
Armed with these data, KX Technologies set out to develop a filter that would remove both the soluble and the insoluble lead portion using a gravity flow filter. However, it first needed to understand how to produce the lead challenge water, which was extremely difficult to produce repeatedly.

The NSF/ANSI Standard 53 pH 8.5 challenge water is made by formulating a simulated water with calcium, magnesium, chlorine and bicarbonate, then removing a fraction of that water to be set aside as a precipitation batch. The original total solution then is saturated with lead, and a large concentration of lead is added to the precipitation batch, which results in the precipitation of the colloidal lead instantly. The precipitation batch is added to the saturated total solution, which keeps the particulate in its precipitated form.

After studying the water characteristics and the process by which the lead was being precipitated, KX Technologies developed a modified protocol to prepare the NSF/ANSI pH 8.5 lead challenge water. It focused on making the precipitation batch separately with very pure water to ensure no contamination or additional ions were present. This resulted in fast precipitation of the particles with no ionic seeds to grow larger particles. Utilizing this protocol, the company was able to make reproducible challenge water and even dial in a desired percent colloidal portion. This procedure for fabricating the pH 8.5 challenge water is currently



Scanning electron micrograph of colloidal lead particles on a 0.1-µm syringe filter



Scanning electron micrograph of media for gravity carafe applications

under evaluation by NSF and other industry laboratories.

Developing a Gravity Filter

The NSF challenge water is a dynamic solution, with the particulate portion shifting back and forth with the soluble portion. When the soluble portion of the challenge water is removed, the particulate portion can go back into solution. This poses a particular challenge for a gravity filter to pass this protocol.

Simply placing a physical barrier to remove the particulate portion will not necessarily remove particulate lead for the life of the filter. Large quantities of soluble lead can inadvertently be dosed into drinking water due to particulate lead accumulating on the filter surface and becoming soluble due to slight pH changes during the test. This can cause the gravity filter to fail.

KX Technologies developed a new approach to gravity filter design based on its FACT technology to meet the high-pH lead protocol. It created a filter with three separate zones of filtration:

- The first zone passes the water through a layer with soluble lead adsorbent. This removes the soluble lead from solution.
- The second zone consists of a physical barrier to stop the particulate lead on the surface. Since the solution is no longer saturated with lead, the particulate lead on the surface of the second zone filter slowly may go back into solution.
- The third zone filter removes any soluble lead that may go back into or remain in solution. This zone uses a FACT filter made with a lead adsorbent. This solution for colloidal lead removal resulted in a patent being awarded in 2011.

Standards Testing

KX Technologies prototyped a filter to meet the specifications outlined in its patent and tested it in a commercially available gravity carafe. The filter was approximately 2 in. OD and 3 in. tall. Two filters were sent to an ANSI-accredited laboratory to be tested to the pH 8.5 lead reduction protocol.

The results are displayed in Table 1. Both filters passed the protocol with an extremely fast flow rate and exceptional lead reductions, despite the wide range of colloidal challenges.

This filter also was tested internally for pH 6.5 lead and chlorine reduction. Figure 2 shows the results of the pH 6.5 lead reduction testing. It showed virtually no lead in the effluent throughout the testing. Internal chlorine testing showed greater than 95% chlorine reduction through the 80-gal tested life of the filter.

Moving Forward

KX Technologies recently presented its modified pH 8.5 lead reduction protocol to the NSF Standard 53 pH 8.5 lead task group for evaluation and validation. This protocol is showing promise to remove some of the variability in test waters between laboratories. *wqp*

References:

1. *Andrew, R. (2008). "NSF Updates Filter Standard to Include Lead Reduction Requirements."* PM Engineer.

2. *Palkon, T. (December 2011). "Getting the Lead Out."* Water Quality Products, *p. 12.*

3. *U.S. Patent 8,002,990 B2, "Uses of fibrillated nanofibers and the removal of soluble colloidal and insoluble particles from a fluid," issued on August 23, 2011.*

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For more information on this subject write in 1003 on the reader service form on page 32.

Figure 1. Total Effluent Particulate Concentration vs. Mean Flow Pore Size

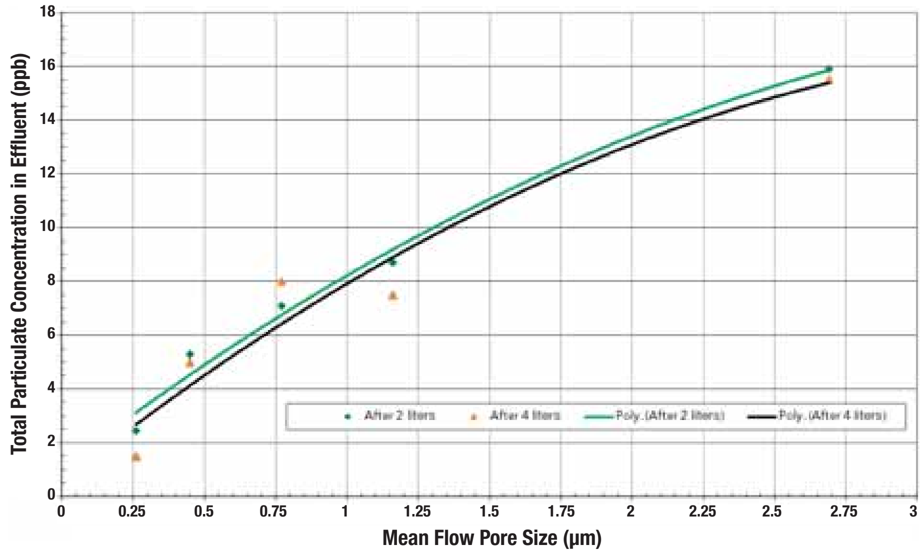

Figure 2. pH 6.5 Lead Reduction Testing

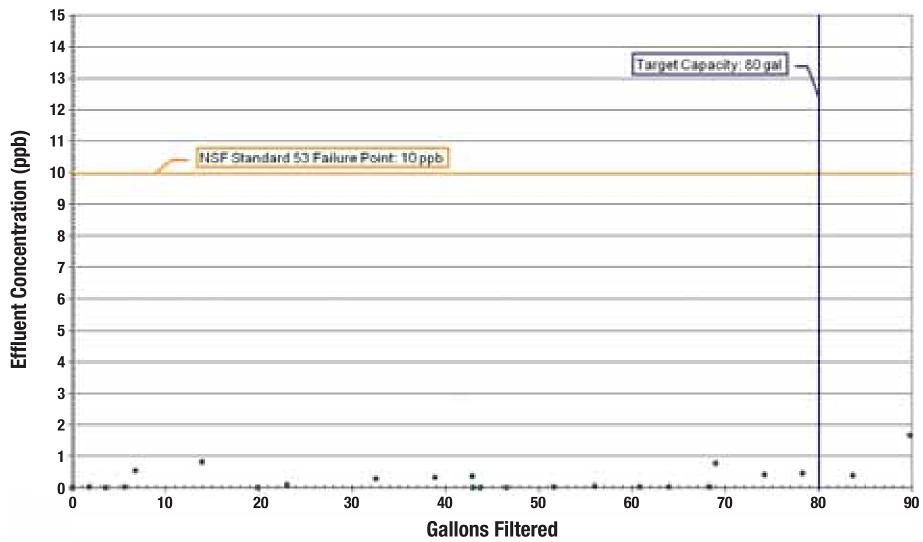

Table 1. Third Party pH 8.5 Test Results

Test Point		Influent Data					Filter 1			Filter 2		
#	Gallons Filtered	Total Lead	0.1 Filtered	1.2 Filtered	% Particulate	% Fines	Flow Rate (mL/s)	Effluent	% Reduction	Flow Rate (mL/s)	Effluent	% Reduction
1	0	145.0	100.6	122.5	30.6%	49%	6.5	0.9	99.4%	6.5	1.1	99.1%
5	20	153.4	91.3	143.6	40.5%	84%	5.1	3.8	97.5%	5.5	3.7	97.4%
9	40	154.3	103.6	139.0	32.8%	70%	4.2	2.0	98.7%	4.2	1.6	98.8%
13	60	148.6	91.6	146.9	38.4%	97%	4.3	4.8	96.8%	4.3	5.0	96.6%
15	72	163.4	102.8	154.5	37.1%	85%	4.5	0.5	99.7%	4.3	0.2	99.9%
17	80	141.0	95.8	112.0	32.1%	36%	4.3	0.8	99.4%	4.2	0.4	99.7%