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APRIL 2023

WQA 2023 Convention & Exposition Preview

**Ion-Exchange
Softening Kinetics**

**Is Wastewater
to Blame for PFAS
at the Tap?**

**What Is Reverse
Osmosis All About?**

**Selecting Water Well
Drills for Better ROI**





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UPCOMING ISSUES

May
Carbon/Small Systems

June
Reverse Osmosis/
Water Reuse & Harvesting

July
Ozone/ Pools & Spas

ON THE COVER



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Viewpoint

WQA Convention & Exposition:
Where Ideas and Opportunities Flow

The 2023 WQA Convention & Exposition, at a brand-new venue right in the heart of the Las Vegas Strip, will be our biggest and best since the pandemic. After two years of steady growth, we have real MOMENTUM heading into this year's event—a perfect reflection of our convention theme.

We're pleased to be able to welcome back many of our international exhibitors, and they seem excited to return. High demand from exhibitors forced us to open up more booth space on the expo floor. With the most advanced water-treatment products displayed under one roof, the expo is the most efficient way to learn about and source cutting-edge products that will help your business get ahead in a rapidly growing market.

Our robust lineup of education sessions will help you update your knowledge on critical topics like PFAS and learn vital business operations skills. Three levels of technical education are geared to those who are new to the industry, those with more advanced expertise, and those interested in commercial-focused applications and research updates.

The Convention keynote speaker is Mae Stevens, senior vice president at Banner Public Affairs, WQA's new government relations firm in Washington, D.C. Stevens is an environmental and water infrastructure policy expert who advocates point-of-use and point-of-entry applications to help deliver safer water. She headlines our Keynote Session, which begins at 3 p.m. on April 18 and also features an exciting mystery entertainment act, the presentation of WQA Leadership Awards, and news and views from industry and association leaders.

All three days of the Convention offer plenty of opportunities to gain critical insights, grow your business and influence, and get more involved in the industry and your trade association. So get excited—and get prepared to join the momentum!



Pauli Undesser, MWS, Executive Director
Water Quality Association and
Water Quality Research Foundation

Meet up with WC&P staff at the
2023 WQA Convention & Exposition
April 18-20



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UNITED STATES

Global Water Resources Appoints Chris Krygier as COO



Global Water Resources, Inc., a water resource management company, has appointed Chris Krygier to the new position of chief operations officer (COO). Krygier previously served as the company's chief strategy officer. As COO, Krygier will be responsible for Global Water's regulated water and wastewater utility operations across its expansion in Arizona. Krygier will also be responsible for leading the company's acquisition and growth initiatives. Krygier brings over 15 years of experience in operations management, regulatory strategy, and capital development for large projects and transactions, along with multistate experience and industry knowledge.

UNH Research Shows Testing Well Water in Warmer Months Leads to Different Results

A new study, coauthored by Ranjit Bawa, a visiting professor at the University of New Hampshire (UNH), investigated water samples from wells across the state of North Carolina and found that the highest levels of bacteria in those wells occurred during warm spells. Bawa said homeowners should test wells in the summer months, when the risk is at its highest. The researchers looked at water samples from 50,000 wells across North Carolina, taken between 2013 and 2018, focusing on wells located near hog farm lagoons. The lowest levels of contamination were found in February and March, and the highest levels were found when temperatures were above 90 degrees.

♦ To submit your announcement, please send the information to WC&P at info@wcponline.com.

Winsupply Inc. Board Names Jeffrey M. Dice as President



The Winsupply Inc. board of directors has elected Jeffrey M. Dice as president of Winsupply Inc. Dice has been a respected contributor to Winsupply's success for more than 18 years. Dice joined Winsupply in 2004 as a regional financial officer and soon moved into internal audit and then into leadership roles. In 2011, Dice was named chief financial officer for Noland Company, and in 2016 he began leading more than 150 employees as senior vice president for Winsupply's Shared and Advisory Services. As president of Winsupply Inc., Dice will lead business strategy development and execution while also overseeing the daily operation of the Winsupply organization.

AWWA Recognizes Dr. Detlef R. U. Knappe with Prestigious A.P. Black Research Award



Dr. Detlef R. U. Knappe, James Ellen Distinguished Professor at North Carolina State University, was awarded the A.P. Black Research Award by the American Water Works Association (AWWA). Knappe has established an internationally renowned research program that studies absorption processes for the removal of organic compounds in drinking water. Knappe's work with characterization of emerging contaminants has led to findings that directly impact the protection of public health. A dedicated leader in advancing fundamental understanding of PFAS, Knappe has published more than 20 articles on PFAS. Knappe leads and participates in multidisciplinary research teams that study the impacts of PFAS on human health and potential treatment approaches to reduce human exposure to PFAS and other unregulated contaminants.

CANADA

CIPH Celebrates 90th Anniversary



2023 marks the 90th anniversary of the founding of the Canadian Institute of Plumbing & Heating (CIPH) on February 18, 1933, in Montreal. In the 1930s, the founding members of CIPH recognized the need to appeal to the government of Canada as a strong, unified voice on behalf of the industry to encourage renovation and housing starts. CIPH's evolution over the past several years, as well as shifts in the environment, regulatory impact, and the changing needs and priorities of the membership, have allowed CIPH to continue to be an active participant in providing programs and services that its members demand.

Brown and Caldwell Promotes Dave Bergdolt as VP to Western Canada



Brown and Caldwell, an environmental engineering and construction service, announced the promotion of Vice President Dave Bergdolt to Western Canada area leader. Bergdolt brings three decades of experience with him, aiding in his ability to help clients in the region overcome environmental and water-related challenges. Bergdolt joined the firm 15 years ago and has since led numerous highly technical projects from conceptual planning through construction and startup, including wastewater facility expansion and upgrades, water-quality improvements, sustainable water supplies, and sewer system rehabilitation. As Western Canada leader, Bergdolt will be responsible for operations management, driving new client growth, and expanding the firm's regional presence in order to meet customer needs.

INTERNATIONAL

33rd Annual Berkeley Springs International Water Tasting Winners



The 2023 Berkeley Springs International Water Tasting gave out the annual awards on February 25, 2023. The award categories and winners are as follows:

Best Municipal Water 2023

- 1st – Clearbrook, BC, Canada
- 2nd – North Muskoka, ON, Canada
- 3rd – Saint Paris, OH, USA
- Tied for 4th – K-Water, Miryang-si, Gyeongsangnam-do, Republic of Korea
- Tied for 4th – Emporia, KS
- 5th – Eldorado Springs, CO

Best Noncarbonated Water 2023

- 1st – Smeraldina Natural Artesian Water, Monti di Deu, Sardinia, Italy
- 2nd – Hope Natural Spring Water, Halifax County, VA
- 3rd – Jano, Village-Blanchard, NB, Canada
- 4th – Floridian Spring Water, Ocala, FL
- 5th – Vortex Energy, Meriden, CT

Best Sparkling Water 2023

- 1st – Dijamant Carbonated Mineral Water, Tešanj, Bosnia and Herzegovina
- 2nd – Antipodes Water, Otakiri, Whakatane, New Zealand
- 3rd – Cedeia Sparkling Mineral Water, Dolomites, Italy
- 4th – Boston Clear Water, Lynnfield, MA
- 5th – Theoni Natural Mineral Water, Karditsa, Greece

Best Purified Drinking Water 2023

- Tied for 1st – Taifer Group 100% Deep Ocean Water, Hualien City, Taiwan
- Tied for 1st – Taiwan Yes Alkaline Minerals Deep Ocean Water, Hualien City, Taiwan
- 2nd – Atomy 100% Deep Ocean Water, Hualien City, Taiwan
- 3rd – VIBRANT WTR, Hamilton, OH
- 4th – Mountain Springs, Saint Kitts and Nevis, West Indies
- 5th – Lesage Natural, Lesage, WV

People's Choice Package Design 2023

- 1st – Antipodes Water, Otakiri, Whakatane, New Zealand
- 2nd – Amamizu Water, Fukui City, Japan
- 3rd – Clearly Canadian, Marchand, Manitoba, Canada **WCP**

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How to Use Artificial Intelligence to Improve Your Digital Marketing



“Why should I work with a local water-treatment company instead of buying online?” I asked OpenAI’s chatbot ChatGPT.

ChatGPT responded, “Expert advice: A local water-treatment company will have trained professionals who can assess your specific water-treatment needs and recommend the best solution for your home or business.

“Personalized service: A local company can provide personalized service and attention to your specific needs and water concerns, rather than just selling you a generic product.

“Convenience: Working with a local company allows you to easily communicate with them and receive prompt service if any issues arise.

“Trustworthiness: Working with a local company allows you to build trust and establish a relationship with the professionals who are working on your water-treatment needs.

“Support the local economy: Choosing to work with a local company helps to support small businesses and the local economy.

“It is important to do thorough research and consider all options before making a decision about your water-treatment needs. Both online and local companies may have their own pros and cons, and it is important to weigh all options and choose the best solution for your specific needs,” ChatGPT responded.

I sat staring at my computer, slightly stunned. I’d tried other AI content generators in the past, and this was blowing them out of the water.

AI Is Already Here

Artificial intelligence (AI) has been an essential part of my world in digital marketing for a long time. Machine learning, a subset of AI, touches nearly every aspect of the work my team and I provide.

A few years ago, our team opted for a manual approach to bidding on keywords for our clients in Google Ads. However, after split-testing Google’s smart bidding options, we found that, in many cases, Google’s machine-learning algorithms can outperform our manual bidding efforts. The great news is that this time savings allows us to spend more time doing things machines currently cannot do well, such as coming up with creative and innovative new ideas for our clients.

With the bursting forth of ChatGPT on the international stage, it is even more apparent to those inside and outside of the digital marketing space that a tangible shift is happening that no one can avoid. Machines are quickly outpacing us in many aspects. The global AI market is booming. It will reach more than \$190 billion by 2025 at a compound annual growth rate of 36.62 percent.¹

It’s easy to let our imagination get the best of us and wonder if we’ll even be able to survive in a world where machines join together, scheming diabolical plots to destroy all humanity. However, it’s more likely that machines will aid us in becoming better versions of ourselves. As usual, it’s up to us to make the most of this ever-changing world and adjust our own mind-sets to take advantage of what’s right in front of us.

Using AI to Improve Lives

Industries all over the world are using AI to improve people’s lives. In one study, researchers from Stanford University used deep-learning algorithms to analyze medical images of skin lesions and accurately identify melanoma, a type of skin cancer. The algorithm achieved accuracy rates that were on par with or better than those of board-certified dermatologists. AI-powered diagnostic tools like this could help identify melanoma at an earlier stage, potentially saving lives and reducing health care costs.²

One language learning app uses AI algorithms to personalize language lessons for users based on the person’s individual learning style and progress. This opens up new opportunities for education and career advancement by helping millions of people around the world easily and effectively learn new languages.³

How can we use AI in the water-treatment industry specifically to improve the success of our digital marketing?

- 1. Marketing communication:** Because of the many hats most employees wear inside a small business, many people struggle with content creation. AI allows us to quickly and easily outline social media ideas, blog articles, and even email sequences.
- 2. Lead generation:** Google and other search engines have leveraged AI for years to show users the right information at the right time. You’ve likely been a part of this process, intentionally or not. How you show up in organic searches, Google Maps, and ads is highly dependent on machine

learning. Understanding how to optimize these systems and train them to get more high-quality leads is a science and an art.

Ask your marketing team what specifically is being done to ensure the algorithms are reaching your ideal target audience, and use that to drive the best traffic to your website. Be sure to also provide to your marketing team data about what is happening to the leads sent to you so the team can further help the machine-learning algorithms increase your marketing return on investment.

- 3. Customer service:** AI-powered chatbots are becoming increasingly popular in customer service and support. Water-treatment dealers can use chatbots to provide instant customer support and answer frequently asked questions, freeing up staff time for more complex tasks. Chatbots can also be used to gather customer data and feedback, which can inform future marketing campaigns.

For example, a water-treatment dealer might use a chatbot on the company website to help customers troubleshoot common problems with their water-treatment systems. The chatbot could also gather customers’ data, such as their location and the types of water-treatment systems they have, which could be used to personalize future marketing messages.

- 4. Email marketing:** AI can be used to optimize email marketing campaigns by analyzing open rates, click-through rates, and conversion rates. Water-treatment dealers can use AI to improve the effectiveness of their email marketing and increase customer engagement.

For example, a dealer might use AI to analyze email marketing data to identify which subject lines and email content are most effective at driving customer engagement. The business could then adjust its email marketing strategy to focus on these elements.

- 5. Social media:** Social media is an important channel for water-treatment dealers to connect with customers and promote their products and services. AI can be used to monitor social media for mentions of a water-treatment dealer or its products. This can help dealers to identify customer feedback and respond in a timely manner, as well as track sentiment and monitor trends.

As the pendulum swings further toward automation, algorithms, and AI, an equal and opposing swing needs to happen to humanize our marketing, operations, and customer service. Ensure you use your humanity to meet people’s emotional needs with your marketing communications. This will help people to connect with you and your team on a deeper level.

At this time, AI for small businesses is not capable of being emotionally intelligent, creating new and innovative ideas, or feeling human emotions. Until this changes, be sure to check how much you’re relying on machines and proactively humanizing your marketing and services.

References

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About the author

◆ Amanda Crangle and the team at Lamplight Digital Media help residential and commercial water-treatment companies profitably grow their dealerships using digital marketing. They have worked with over 100 water-treatment dealerships spanning North America, managed millions of dollars in ad spend, and performed over 1,000 scientific website split tests. Crangle intimately knows the water industry, having worked in a dealership as a sales rep and as a general manager.



Upcoming Events

Highlighted listings denote WC&P attendance or distribution (subject to change).

April 2023

- 11-14

Texas Water Week
Houston, TX, USA
<https://www.txwater.org/>
- 16-19

American Water Works Association Sustainable Water Management Conference
Minneapolis, MN, USA
<https://www.awwa.org/Events-Education/Sustainable-Water-Management>
- *18-20

2023 WQA Convention & Exposition
Las Vegas, NV, USA
<https://convention.wqa.org/>
- 22

Earth Day
- 24-25

National Groundwater Association Managed Aquifer Recharge: Unleashing Resiliency, Protecting Groundwater Quality
San Antonio, TX, USA
<https://www.ngwa.org/detail/event/2023/04/24/default-calendar/23apr5029>
- 24-29

Water Week 2023
Washington, DC, USA
<https://www.waterweek.us/>

May 2023

- 1-3

American Filtration & Separations Society FiltCon 2023
Louisville, KY, USA
<https://filtcon.memberclicks.net/>
- 7-13

Drinking Water Week
<https://www.awwa.org/Events-Education/Drinking-Water-Week>
- 8-10

Global Water Summit 2023
Berlin, Germany
<https://www.watermeetsmoney.com/>
- 9-11

Association of California Water Agencies 2023 Spring Conference & Expo
Monterey, CA, USA
<https://www.acwa.com/events/2023-spring-conference-exhibition/>
- 9-11

Arizona Water Association Annual Conference
Phoenix, AZ, USA
<https://www.azwater.org/group/annualconference>
- 17-18

BlueTech Forum 2023: Innovation with Impact
Edinburgh, Scotland
<https://www.bluetechforum.com/>

- 28-June 2

18th International Water Association Leading Edge Conference on Water and Wastewater Technologies
Daegu, South Korea
<https://iwa-let.org/programme-2023/>

June 2023

- 5-7

Aquatech China 2022
Shanghai, China
<https://www.aquatechtrade.com/china>
- 7-9

Florida Water Quality Association 2023 Conference & Trade Show
Orlando, FL, USA
<https://fwqa.com/events/convention-2023/>
- 6-9

Water Environment Federation Innovations in Process Engineering Conference
Portland, OR, USA
<https://www.wef.org/events/conferences/upcoming-conferences/ProcessEngineering/>
- 18-20

Canadian Institute of Plumbing and Heating Annual Business Conference 2023
St. John's, Newfoundland and Labrador, Canada
<https://www.ciph.com/events/EventDetails.aspx?id=1688872&group=>

- 27-29

Water Environment Federation Stormwater Summit
Kansas City, MO, USA
<https://www.wef.org/events/conferences/upcoming-conferences/stormwatersummit/>

July 2023

- 11

U.S. National Swimming Pool Day
- 17-19

American Water Resources Association 2023 Summer Conference
Denver, CO, USA
https://www.awra.org/AWRA/Members/Events_and_Education/Events/2023_Summer_Conference/2023_Summer_Conference.aspx

- 17-20

50th Annual Texas Water Quality Association Convention & Exhibition
Montgomery, TX, USA
https://twqa.org/events_convention.php

- 23-26

10th International Water Association Membrane Technology Conference
St. Louis, MO, USA
<https://mtc2023.wustl.edu/>

August 2023

- 20-24

World Water Week 2023
Online and in Stockholm, Sweden
<https://worldwaterweek.org/>

- 22-24

The Water Expo
Miami, FL, USA
<https://www.thewaterexpo.com/>

September 2023

- 5-7

Aquatech Mexico
Mexico City, Mexico
<https://www.aquatechtrade.com/mexico>
- 10-12

Smartwater Summit
Scottsdale, AZ, USA
<https://www.smartwatersummit.com/>
- 11-14

Water JAM 2023
Virginia Beach, VA, USA
<https://www.vwea.org/events/EventDetails.aspx?id=1566801&group=>
- 13-16

Water Indonesia 2023
Jakarta, Indonesia
<https://waterindonesia.merebo.com/>
- 24-28

IAPMO 94th Annual Education and Business Conference
San Antonio, TX, USA
- 30-4

WEFTEC 96th Annual Technical Exhibition & Conference
Chicago, IL, USA
<https://www.weftec.org/>

October 2023

- 11-12

Pacific Water Quality Association 66th Annual Trade Show & Convention
Irvine, CA, USA
<https://pwqa.com/>

- 15-18

International Desalination Association Seville Summit on Water and Climate Change
Seville, Spain
<https://wcc.idadesal.org/>

- 25-26

World Water-Tech North America
Los Angeles, CA, USA
<https://worldwatertechnorthamerica.com/aboutus/>

November 2023

- 6-9

Aquatech Amsterdam
Amsterdam, The Netherlands
<https://www.aquatechtrade.com/amsterdam>

December 2023

- 10-14

International Water Association Water and Development Congress & Exhibition
Kigali, Rwanda
<https://waterdevelopmentcongress.org/WCP>

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Water Quality Association 2023 Convention & Exposition



SCHEDULE

(all dates and times subject to change)

Monday, April 17, 2023

8:00 AM-4:00 PM

Business Boot Camp (Additional Fee Applies)

Speakers: Amanda Crangle, Lamplight Digital Media; Mike McGowan, MWS, McGowan Water Conditioning Inc; Dustin Martin, Martin Water Company; Lisa Stich, Watts Water Technologies; Kim M. Redden, MPH, MWS, Pentair Water Purification; Candice M. Wentling, MWS, Certified Action

9:00 AM-6:00 PM

PFAS Symposium

1:00 PM-5:00 PM

Commercial/Industrial RO Sizing Workshop (Separate Registration Required)

Presenter: Peter S. Cartwright, MWS, PE, Cartwright Consulting Company



Tuesday, April 18, 2023

7:30 AM-5:00 PM

Registration Open

8:00 AM-8:50 AM

More Than a Sale: Ethics and PFAS

Moderator: Candice M. Wentling, MWS, Certified Action
Panelist: Eric Yeggy, MWS, Water Quality Association

9:00 AM-9:50 AM

I Bought a Water Company. Now What?

Panelists: Paul Friot, MWS, CI, CWR, Get Water Answers, and Kelly Thompson, MWS, CI, Moti-Vitality

PFAS Regulations and Testing

Presenter: Marianne Metzger, ResinTech, Inc.

Processes Produce Profits

Speaker: David Brewster

WQRF Research Reports

Co-Presenters: Kayla Heriaud and George Zhou, PhD, Purdue University

Tuesday, April 18, 2023 [continued]

10:00 AM-10:50 AM

Continuous Disinfection - Calculating Chlorine Solution & Injection Pipe Sizing

Presenter: Greg Reyneke, MWS, Red Fox Advisors

Dealer Section

Water Sciences Committee

Wells 101

Presenter: Cliff L. Fasnacht, MWS, Pacific Purification Inc

10:00 AM-10:25 AM

Wildfires

Presenter: Shannon Murphy, Aquamor LLC

10:30 AM-10:55 AM

Drinking Water and Plumbing Chemical Contamination Challenges

Presenter: Andrew Whelton, PhD

11:00 AM-11:25 AM

Chlorine & Nitrification in Plastic Pipe

Presenter: Patrick Gurian, Drexel University

11:00 AM-11:50 AM

Chlorine Dioxide

Presenter: Dean Gregory

Creating a Self-Generating Sales Team

Speaker: Jennifer Smith, CWS, CWS, Moti-Vitality

Residential Anion Resin Applications & Considerations

Presenter: Bill Koebel, ResinTech, Inc.

Well Disinfection

Presenter: Joseph Huemann, CWS, CI, Huemann Water Conditioning

11:00 AM-1:00 PM

Lunch available for purchase

1:00 PM-1:50 PM

Manufacturer Section

Rainwater Harvesting

Presenter: Denis Rochat

1:00 PM-2:50 PM

Problem Water/Testing, Applications, and Solutions

Co-Presenters: Marianne Metzger, ResinTech, Inc., and Tate Burckhardt, Better Water Industries Inc.

Tuesday, April 18, 2023 [continued]

2:00 PM-2:50 PM

Clack Control Valve Overview and Valve Teardown

Presenter: Douglas Haring, MWS, CI, CWR, Clack Corporation

Greywater Reuse-Residential, Commercial, Industrial

Speaker: Melissa Lubitz, Hydraloop Inc.

RISE/THRIVE/WIN

Where Do Membrane Technologies Fit in Water and Wastewater Treatment?

Presenter: Peter S. Cartwright, MWS, PE, Cartwright Consulting Company

3:00 PM-4:30 PM

Keynote Session

Speaker: Mae Stevens, Banner Public Affairs

Wednesday, April 19, 2023

7:30 AM-5:00 PM

Registration Open

8:00 AM-8:50 AM

Consumer Opinion Study

Introduction to Softener Efficiency

Presenter: Douglas Haring, MWS, CI, CWR, Clack Corporation

Tannins & Silica Reduction Using Ion Exchange

Presenter: Bill Jandrich, Purolite

9:00 AM-9:50 AM

10 Marketing Strategies for Tomorrow

Speaker: Dale "Data Dale" Filhaber, Dataman Group Direct

Colloids

Presenter: Michael D. Heatwole, MWS, A O Smith/ Water-Right

Industry Research Committee

Joint Federal Government Affairs Committee & Regional/State Government Affairs Committee

Softening Water with High TDS

Presenter: Charles F. Michaud, MWS, Systematix Company

9:00 AM-9:25 AM

Water Quality Matters for Coffee Taste and Coffee Machines

Presenter: Cang Li, PhD, Kinetico Incorporated

Feature

Wednesday, April 19, 2023 [continued]

10:00 AM-10:50 AM

Business Operations Panel Session

Moderator: Derek Packard, CWS, Packard Culligan
Panelists: Chris West, CWS, C-Tech Water Solutions, LLC, and Jami West, C-Tech Water Solutions, LLC

Commercial/Industrial Section

Communications Committee

Smart Valves & Leak Detection-State of the Industry

Panelists: Tim Hammack; Dave Smith, AQ Matic; Jorge Zu-koski, Best Water Solutions, Inc

State & Regional WQAs Section

WQRF Studies: How to Use These Studies in Your Marketing and Sales Presentations

Presenter: Jennifer Smith, CWS, Moti-Vitality

10:00 AM-10:25 AM

Lead Exposure Assessment Device

Presenter: Darren Lytle, PhD, PE, U.S. Environmental Protection Agency

10:30 AM-10:55 AM

Chlorine Conversion Impact on Pathogen Occurrence, Residual Level, and DBP Formation in a Distribution System and Premise Plumbing

Drought Effects on Water Quality/SAFER Program Update

11:00 AM-5:00 PM

Exposition

11:00 AM-2:00 PM

Lunch available for purchase

5:00 PM-6:30 PM

Networking Reception



Thursday, April 20, 2023

7:30 AM-2:00 PM

Registration Open

8:00 AM-8:50 AM

Adapting Water Needs for Current Building Design — The Water Demand Calculator

Presenter: Christoph Lohr, IAPMO

Find Fulfillment Through Leadership Effectiveness

Speaker: Candice M. Wentling, MWS, Certified Action

Toilet Talk-Lessons from Looking in the Back of the Toilet

Presenter: Michael D. Heatwole, MWS, A O Smith/ Water-Right

WQRF Predictive Modelling

9:00 AM-2:00 PM

Exposition

11:00 AM-1:30 PM

Lunch available for purchase



2023 WQA SHOW FLOORPLAN [As of March 14, 2023—subject to change]



ENTRANCE

2023 WQA EXHIBITOR LISTING [Subject to change]

COMPANY BOOTH

1 3AC Co., Ltd. 350

2 A. O. Smith Water Treatment (North America), Inc. 701

3 Acuva Technologies Inc. 1043

4 Advantage Controls 230

5 AdvanTech Aqua 221

6 Aerus, LLC 311

7 Ahlstrom-Munksjö Filtration LLC 945

8 All Filters 541

9 Alpine Coolers 940

10 AmeriAsia Filtration Technology Co.,Ltd. 535

11 American Water Solutions, LLC 627

12 Anhui Chiro Technology Co., Ltd. 941

13 Applied Membranes, Inc. 439

14 Applied Process Equipment Inc. 934

15 Aqua Finance, Inc. 513

16 Aquafilter Europe 450

17 Aquametrics Enviromental 1152

18 Aquatech Global Events 949

19 AquaviWater 328

20 AquiSense Technologies 330

21 ARM Solutions 222

22 Arrow Industries Div. ELBI of America 819

23 Atlas Filtri North America LLC 827

24 AXEON Water Technologies 1121

25 Better Water Industries, Inc. 237

26 Biocera Co., Ltd. 449

27 Blupura 727

28 Brio Water Technology, Inc 401

29 Canadian Water Quality Association 1049

30 Canopus Water Technologies Inc. 946

31 Carbon Activated Corp. 340

32 Carbon Block Technology 519

33 Cargill Salt 419

34 Caware Filtering Corporation 838

35 Charger Water Treatment Products, LLC 907

36 Chester Paul Company 819

37 Clack Corporation 211

38 Clover Co., Ltd. 634

39 Compass Minerals 747

40 Cosmetal 925

41 Coster Engineering 751

42 Crystal IS 231

43 Crystal Mountain Products Inc 540

44 Cuckoo Electronics America, Inc. 640

45 DAB Pumps, Inc. 448

46 Dataman Group Direct Marketing Services 326

47 Dawnway Enterprise Co., Ltd 346

48 Dividend Finance 550

49 Dong Guan YuLia Electronic Technology Co., Ltd 342

50 DROP Connect 1009

51 Ecolife Technologies, Inc. 919

52 EMSL Analytical, Inc. 206

53 ENPRESS LLC 934

54 Farris Enterprises, Inc. 1048

55 Filtteck Co., Ltd 848

56 Flexcon Industries 324

57 Fluxtek International Corp 1147

58 Foamulations / CuZn Water Systems 734

59 Foshan Shunde BPSAFE Environmental Technology Co., Ltd 1040

60 Foundation Finance Company 241

61 Franklin Water Treatment 201

62 G.A. Murdock, Inc. 739

63 Global Aqua Technology 1115

64 Global Water Solutions USA 913

65 Good Water Warehouse, Inc. 901

66 Guangdong Coolway Technology Co., Ltd. 637

67 Handok Clean Tech Co., Ltd. 845

68 Hangzhou Naiad Water Purification Technology Co., Ltd. 952

69 Hangzhou Srilan Filtration Technology Co., Ltd. 1148

70 Hankscraft Runxin LLC 931

71 Happle Printing 240

72 Harmsco Filtration Products 851

73 Haycarb USA, Inc. 542

74 Healthway 539

75 Hebei UMEK Environment Machine Co., Ltd 635

76 Hidrotek Co., Ltd. 445

77 Hydro Flow Filtration Systems 321

78 Hydronix Water Technology 527

79 Hydrotech (a division of Canature WaterGroup) 601

80 IAPMO R&T 937

81 iControls Technologies Inc. 255

82 IHLAS EV ALETLERI IMALAT SAN TIC.A.S 841

83 Impact Water Products 325

84 INDOCARB AC LLC 225

85 Industrial Test Systems, Inc. (ITS) 337

86 International H2O Inc 518

87 Inversand Company 741

88 ION EXCHANGE LLC 743

89 JACO Manufacturing Company 942

90 Jintec Co., Ltd. 740

91 John Guest / RWC 1019

92 Jubei Group 736

93 KDF Fluid Treatment, Inc. 953

94 Kinetico Incorporated 1001

95 Know My Water 450

96 Lake Industries 245

97 LaMotte 947

98 Lamplight Digital Media, LLC 735

99 Le Fay / Apollotek, Inc. 548

100 LeverEdge 420

101 Liquid Soap Products 220

102 Luminor Environmental Inc. 336

103 M.L. Ball Company, Inc. 440

104 Marlo, Inc 329

105 Membrane Solutions,LLC. 1050

106 Micro Display Inc., (Micro Pure Inc.) 1052

107 Mid America Water Treatment, Inc. Int 1037

108 Morton Salt Co. 212

109 Moti-Vitality 524

110 Myron L® Company 1015

111 National Testing Laboratories, LTD 546

112 Navien, Inc. 1025

113 Nelsen Corporation 619

114 Neoperl, Inc. 424

115 Next Filtration Technologies Inc. 834

116 Nichia America Corporation 453

117 Ningbo HO Water Purification Technology Co., Ltd. 749

118 Ningbo Zuanbang Technology Company, Ltd. 1046

119 NSF International 433

120 Oasis International 1031

121 Omnipure Filter Company, Inc. 613

122 Onyx Specialty Papers, Inc. 443

123 Orenco Controls 355

124 Oxidizer Pro 229

125 Paragon Water Systems Inc 719

126 Parker Hannifin 944

127 PENCA IMPORT AND EXPORT COMPANY LIMITED 452

128 Picogram Co., Ltd. 430

129 PlainLiv Taiwan Co., Ltd. 1044

130 POLYMEM 948

131 Polymer Solutions International, Inc. (PSI) 427

132 Precision Installation Products, Inc. 413

133 Prism Visual Software, Inc. 1150

134 Pro Products LLC 835

135 PURE & GENTLE SOAP 320

136 PureGen Technology, Inc. 1133

137 Puretek Co., Inc. 1127

138 Puretek 227

139 Purified Technologies, LLC 451

140 Purolite, An Ecolab Company 1109

141 Qili Water Resources Co., Ltd. 641

142 Qingdao Ecopure Filter Co., Ltd. 331

143 Quench 442

144 R.Bardi Srl 224

145 ResinTech, Inc. 713

146 Rusco 840

147 SAFEWAY WATER LLC 846

148 Samyang Corporation 1136

149 Scotwood Industries LLC 839

150 SEONE Co., Ltd. 242

151 ServiceTitan 436

152 SGC 352

153 Siam Cast Nylon Co., Ltd. 423

154 SIP Topology Environmental Protection and Purification Co., Ltd. 1143

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163 Taiyuan Lanlang Technology Industrial Corp. 243

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165 Tianjin Tianchuang Best Pure Environmental Science and Technology Co., Ltd. 1142

166 Tigerflow Systems, LLC 208

167 Time Investment 526

168 UNCO Data Systems, Inc. 735

169 United Filters International 347

170 United Salt Corporation 251

171 UNITIKA LTD. 249

172 US Nuclear Corp 847

173 UV Pure Technologies Inc. 341

174 UVDynamics Inc. 1053

175 Vertex Water Products 214

176 VIQUA 301

177 Voltea 236

178 Water Conditioning & Purification Magazine 348

179 Water Purification Supplies 1036

180 WaterColor Management dba MPR-Fintra Alabama, Inc. 429

181 Wateropolis Corp. 253

182 Watts 1139

183 WONBONG CO., LTD. 842

183 ZILMET USA 446

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Refreshingly Simple

Ion-Exchange Softening Kinetics: Max Flow Explained

We all know how much wood a woodchuck could chuck if a woodchuck could chuck wood, but how fast can you run a one cubic foot softener? What does the “max flow” mean for an NSF/ANSI 44-listed softener, and what happens if that flow is exceeded? When I posed that question to a group of experts about 20 years ago, I got answers ranging from “nothing” to “total failure.” One of those answers is close to correct.

Kinetics is the branch of science that deals with the rate of change of a chemical reaction or system. But how fast is the water-softening reaction, and what factors control it? Water temperature could play a big role in how fast a softener can react. Since ion exchange is a diffusion process, particle size of the resin is important, and the ease with which ions can enter and exit the resin structure plays a key part, as well. That is controlled by the cross-linking level. Regeneration level and water composition impact capacity and leakage of a resin but not the rate at which ions exchange.

Impact of Temperature

Between water temperatures of 60°F and 80°F, capacity improves by only about 5 percent. However, although cold water can be treated with a softener, cooler water (50°F) sees a steep drop in capacity, and temperatures below 40°F can cost you 50 percent in capacity due to the slower kinetics of the exchange reaction.

Bed Depth

The real bottleneck in an ion-exchange reaction is the rate of diffusion through the static zone right next to the surface of the bead (called the Nernst layer). Diffusion of ions through the Nernst layer is as much as 10 times slower than diffusion

through the bead itself. The faster the superficial flow through the resin bed, the thinner the Nernst layer becomes. Providing enough bed depth by using a narrower but deeper bed can improve the capacity of the bed and, therefore, has a positive kinetic effect. One cubic foot of resin in an 8-inch vessel will show a 16 percent increase in capacity over that of a 10-inch vessel at 10 gallons per minute (gpm).

Mesh Size

The size range for standard softening resins is from 0.3 millimeter to 1.2 millimeters, a factor of 4x. Those larger beads are 16 times slower than the smaller ones. In addition, coarse resins will have thicker Nernst layers. The differences between a fine mesh resin (40-60 mesh) and a coarse resin (12-30 mesh) can be as much as 30 percent in capacity due to kinetics. The primary advantage is in the ability of the finer mesh beads to regenerate more thoroughly with a given salt level.

How Fast Is Max Flow?

Since many kinetic reactions are driven by concentration, it is not difficult to understand that ion exchange is also driven by concentration. The kinetic equilibrium equation is as follows:

$$K = \frac{Ca [Ca^{++}]_w [Na^+]_R}{Na [Ca^{++}]_R [Na^+]_w}$$

The larger the numbers in the numerator, the more favorable the reaction. The larger the numbers in the denominator, the slower the reaction.

We can see that as hard water travels through the bed, the amount of calcium (Ca) in the water decreases, as does the amount of sodium (Na) on the resin. Further, the amount of calcium on the resin increases, as does the amount of sodium in the water. With the numerator decreasing and the denominator increasing, we can see that the reaction is slowing down. The point at which two forces equal one another is called the equilibrium, and there the reaction stops.

Half-Lengths

The concept of half-lengths is often used in adsorption reactions to estimate retention time needed. It can also be applied to ion-exchange reactions. Simply stated, if it takes X amount of time to complete 50 percent of a reaction, it will take the same amount of time to complete 50 percent of what is left. In other words, if it takes 10 seconds to complete 50 percent of the softening process, it will take 10 seconds more to complete 25 percent additional softening, and 10 seconds to treat the next 12.5 percent, and 10 seconds to complete the next 6.25 percent, and so on, with each time interval completing half of the remaining process. Although this concept does not calculate to 100 percent complete, it can be shown that at 7 half-lengths, we are at 99.25 percent complete, and at 10 half-lengths, we arrive at 99.95 percent complete.

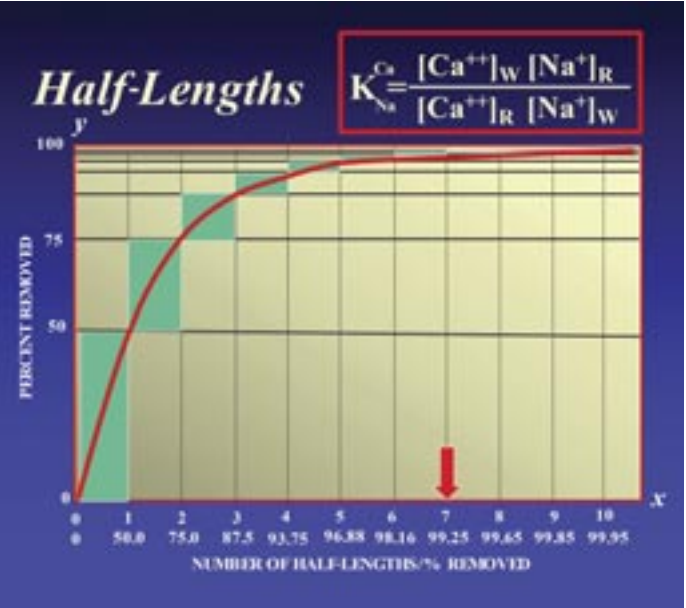


Figure 1. A graphic representation of half-lengths.

You never know your top speed until you try to exceed it. A well-run softener will reduce 20 grains of hardness to less than 0.2 grains. That's 99 percent, or 7 half-lengths. To test our hypothesis on max flow, we tested a 10-inch softening cartridge on city water with 17 grains per gallon (gpg) hardness. Our effluent tested 0.20 gpg. This was a reduction of 98.8 percent, which we called 99 percent, and established what the equilibrium softening capability on that feed water would be.

Using fresh cartridges made with 8 percent and 10 percent softening resin, we then ran flat out with hopes of exceeding

the “just barely” softened flow rate. We were successful, with flow rates approaching 250 gallons per minute (gpm) per cubic foot (cu ft). The data is presented in Figure 2.

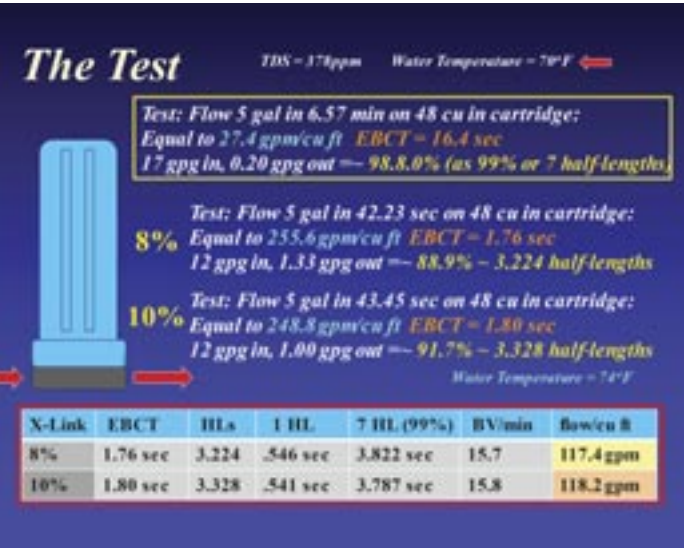


Figure 2. Testing the limits of softener kinetics.

Discussion of Results

With our 8 percent resin cartridge containing 48 cubic inches (cu in) of resin, we filled a 5-gallon bucket in 42.23 seconds. That gave us an equivalent flow rate of 255.6 gpm/cu ft and an empty bed contact time (EBCT) of 1.76 seconds. The feed water was tested at 12 gpg and softened to 1.33 gpg. That calculates to 88.9 percent softening, or 3.224 half-lengths. One half-length is calculated to be 0.546 seconds (1.76 seconds/3.224). Seven half-lengths is 3.822 seconds. This is the equivalent of 15.7 bed volumes (BVs) per minute (60/3.822) or 117.4 gpm/cu ft.

We repeated the testing with a 10 percent resin cartridge and calculated the max flow at 118.2 gpm. We noted that over the course of the testing, the feed water had warmed slightly from 70°F to 74°F, which may account for the slightly faster kinetics of the 10 percent resin.

Conclusions

Some dealers may upsell a residential user based on what's parked in the driveway. However, that 12,000-square foot manse on the five-acre lot sporting a 28 gpm fixture count for a two-kitchen, eight-bathroom bungalow could probably get by with a 1 cu ft softener. The only reason to upsize would be that the total water usage per day exceeds the capacity of the 1 cu ft unit.

The kinetics of a water softener are surprisingly fast. A variable flow end-user needing 5 gpm with spikes of 25 gpm need not require a large system to cover the spikes. Pay attention to pressure drop, however. A 1 cu ft softener running at 10 gpm may experience a pressure loss of 10 pounds per square inch (psi). Trying to push that same system to 25 gpm will incur a pressure loss over 50 psi. Because the softening reaction is

Feature

By C.F. "Chubb" Michaud

completed farther down in the vessel, higher flows mean lower capacity. If running 1 cu ft at 3 gpm produces a capacity of 24,000 grains, running at 10 gpm will see a drop to 22,000 grains, and 50 gpm will provide only 12,000 grains.

This all pertains to residential uses only. Commercial and industrial systems are designed more for total capacity and tend to be larger due to the demand for continuous flow and total water volume per day. A residence with a peak flow of 10 gpm may still use only 400-500 gallons per day. An industrial user with a continuous 10 gpm demand will use 14,000 gallons per day, and at 15 gpg needs to remove 216,000 grains of hardness every 24 hours while exhausting 9 cu ft of resin. The ideal design for this use is a twin alternating 5 cu ft softener.

NSF 44

Max flow is not a physical flow limitation, but, instead, it is the flow at which the pressure drop equals 15 psi. If you exceed the flow, the pressure drop increases.

Takeaways

The ion-exchange process is a complex mass-transfer sequence that is diffusion-rate limited. Better kinetics favors the use of smaller beads, lower cross-linked resin, warmer water, deeper beds, and dilute solutions. You are not likely to ever overrun a softener with high flow alone. **WCI**

About the author

♦ C.F. "Chubb" Michaud, MWS, is the technical director and CEO of Systematix Company of Buena Park, CA, which he founded in 1982. He has served as chair of several sections, committees, and task forces within the Water Quality Association (WQA), as well as served as a past director and governor. He served on the Pacific Water Quality Association (PWQA) board, chairing the Technical and Education Committees for 12 years. Michaud is a proud member of both the WQA and PWQA Halls of Fame, has been honored with the WQA Award of Merit, and is a two-time recipient of the PWQA Robert Gans Award. A frequent and well-published author and speaker, Michaud has contributed over 100 original papers on water-treatment techniques and holds four U.S. patents on ion-exchange technologies. He holds a BS and an MS degree from the University of Maine.



About the company

Systematix Company, founded in 1982, is an innovative media supply company with a focus on ion-exchange media, processes, and systems design. Expert advice is offered for the asking. The company can be reached at (714) 522-5453, or email askchubb@aol.com.



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PFAS Coming Out of the Tap? Maybe Your Wastewater's to Blame

By now, most water professionals have heard of PFAS, those pesky synthetic chemicals that can cause so much damage to human health but are so hard to get rid of. Thankfully, there are commonly available technologies that can remove them from tap water, but these solutions can be expensive, and not everybody has access to them. So how did PFAS get into the drinking water supply, and what can be done about them?

Why PFAS Are Here to Stay...for Now Anyway

The PFAS problem began in 1938, when DuPont researchers accidentally discovered polytetrafluoroethylene, a chemical that repels water and oil very effectively. It wasn't until after World War II that the company got around to commercializing the discovery into a product called Teflon. Since then, other chemical manufacturers have developed a slew of PFAS to be used in everything from firefighting foams to waterproof clothing. PFAS are also frequently used in industry as a lubricant or surfactant.

What makes a PFAS a PFAS—and gives it such useful properties—is the chemical structure of the compound. The scientific name for the category of chemicals we refer to as PFAS is per- and polyfluoroalkyl substances. To belong to this group, a compound must have at least one carbon-fluorine bond. This bond is the strongest in nature and one of the reasons water professionals will be dealing with PFAS for many years to come. PFAS chemicals that were disposed of decades ago in long-forgotten landfills or wastewater ponds are still around today.

One of the most infamous examples of the problematic endurance of PFAS involves the Wolverine World Wide shoe manufacturer in Michigan. Wolverine used a PFAS compound supplied by 3M to waterproof the shoes and boots made in its Rockford, Michigan, facility. Sludge from the tannery was disposed of in

a landfill owned by the company. Although the landfill was closed down decades ago, the tannery landfill was discovered much more recently to be a source of PFAS in the local water supply, leading to a slew of lawsuits, some of which are ongoing.

The PFAS Keep Coming

The other reason PFAS are here to stay is because they are so useful, and new PFAS can be produced to replace PFAS that are determined to be toxic. There are over 5,000 PFAS compounds known today, and since they are all similarly structured, it is generally believed that they all have a similar impact on human health and the environment. The question is, to what degree?

While all PFAS contain at least one carbon-fluorine bond, studies suggest that the number of bonds in a chemical has an impact on toxicity. In general, long-chain compounds are those that contain seven or more bonds. Short-chain compounds are those that contain fewer than seven. Available toxicity assessments indicate that long-chain PFAS compounds are likely to be more toxic than short-chain compounds.

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), for example, are two long-chain, highly toxic PFAS compounds that were voluntarily discontinued in the United States years ago. (These compounds are still imported into the U.S. via commercial and industrial products.) The original U.S. manufacturers of PFOA and PFOS have created short-chain compounds to replace their more toxic predecessors. PFOA was largely replaced with a compound referred to as GenX that contains six carbon-fluorine bonds, and PFOS was replaced with perfluorobutane sulfonic acid (PFBS), a compound that contains four carbon-fluorine bonds. The U.S. EPA recently completed toxicity assessments for GenX and PFBS. While these

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compounds are considered toxic, the resulting health advisories are set at much higher levels than those for PFOA and PFOS.

As consumers continue to want products that are waterproof, nonstick, and oil resistant, PFAS will continue to be used. As some PFAS are more tightly regulated, other PFAS will take their place. A few states are attempting to outlaw products that include PFAS—see California’s most recent ban on PFAS in textiles and cosmetics—but laws like this aren’t gaining much traction at the federal level, since not enough is known about the relative toxicity values of the PFAS family of compounds. So, PFAS are here to stay.

Why Wastewater Treatment Isn’t the Answer

Today’s water-treatment systems are highly sophisticated and can address contamination from a wide variety of chemicals and biological organisms. Unfortunately, traditional wastewater treatment does not remove PFAS from wastewater. If you’ve discovered PFOA or PFOS in your water and can’t find the source, work with your local wastewater treatment partners to look for PFAS precursors in wastewater influent. Here are a few sources to look for:

Local industry. The first place most think to look is at the businesses in the affected area. Chemical manufacturers are the obvious possible culprits, but other types of businesses, such as metal finishing and textile manufacturers, can be a source.

Storm water runoff. This runoff may be from an industrial site where PFAS is manufactured or used, but there are other sources to consider. For example, Boston has gone so far as to prohibit AstroTurf in public parks due to the potential of PFAS (and a variety of other compounds) in runoff from these sites.

Airports and military sites. Aqueous film-forming foam, the foam used to fight Class B chemical fires, often contains PFAS. Runoff from sites where this foam has been used, either in an emergency or training exercises, typically hits the storm sewer system and is then sent to the local wastewater treatment facility.

Landfill leachate. As liquid (e.g., rain, condensation, or liquid waste) passes through a landfill, it can leach PFAS from solid waste containing PFAS. This contaminated leachate is typically sent to the local wastewater treatment facility, where it can enter the water supply.

Testing Wastewater for PFAS

One of the other challenges with PFAS in wastewater is testing a liquid that contains varying degrees of solids. The test methods for drinking water (Method 533 and Method 537.1) validated by the U.S. Environmental Protection Agency (EPA) aren’t appropriate, so the agency is actively working on two test methods in conjunction with other organizations, including the U.S. Department of Defense and authorized labs:

- **Draft Method 1633** can quantitate 40 unique PFAS compounds across a wide range of solid and aqueous matrices, including wastewater, and leachate.
- **Draft Method 1621** is a screening method designed to quantify total organic fluorine at the parts-per-billion level in all aqueous matrices.

Once finalized, methods 1633 and 1621 will support a variety of EPA initiatives to monitor—and eventually regulate—PFAS in non-potable waters. In fact, even though Method 1633 has not yet passed the multi-lab validation phase, the EPA issued a memo requiring it for National Pollutant Discharge Elimination System permitting. Method 1621 may also be used.

Total oxidizable precursor (TOP) assay is another test method. Some wastewater treatment processes can convert PFAS precursors into terminal PFAS such as PFOA and PFOS. This method oxidizes these precursors to turn them into terminal PFAS compounds that can then be measured. The increase in PFAS measured after the TOP assay oxidation relative to preoxidation levels is a worst-case estimate of the total concentration of PFAS precursors present in a sample. This analysis is particularly useful in forensic studies designed to identify the source of elevated PFAS levels in finished drinking water.

Water Filtration’s Catch-22

Thankfully, there are solutions, such as granular activated charcoal (GAC) water filtration, that have been shown to remove PFAS from drinking water supplies. Some municipalities are spending thousands to implement such solutions locally.

However, while GAC filtration provides immediate protection for the public, it’s not without its drawbacks. It can be expensive. Moreover, activated carbon filters do not destroy PFAS; they only contain it. Municipalities are then faced with the problem of disposing of the contaminated filters. Incineration has been shown to spread PFAS particles through stack emissions, and sending the filters to the landfill just recycles the PFAS back into the water supply through the leachate.

However, many companies and research facilities are working on ways to destroy PFAS in the environment, including the cultivation of PFAS-eating microbes and chemical “decapitation.” Until then, water professionals will need to monitor their water supply and search for the source of PFAS when elevated levels are discovered. Testing wastewater influent and effluent is often the place to start your forensic effort. [WQ](#)

About the author

◆ Nick Nigro is a product manager at Pace Analytical, responsible for PFAS operations at seven emerging contaminant centers of excellence within Pace’s nationwide network of environmental testing laboratories.



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What Is Reverse Osmosis All About?

The Technology

Reverse osmosis (RO) is a water-treatment technology that utilizes atomic filtration to remove contaminants from water. The key to this removal is a special membrane that basically holds back, or rejects, almost all contaminants, including sediment, microorganisms, dissolved organics, and even salts and minerals, while allowing purified water to pass through. The rejected contaminants are swept away from the membrane surface and continuously discharged to the drain during operation.

In other words, one water stream enters the membrane device, and two streams exit. One is purified water (permeate) and the other (concentrate) contains most of the waterborne contaminants. The driving force for this separation is water pressure, usually from a pump.

Arguably the most practical and effective residential drinking-water treatment system, RO will remove over 90 percent of salts and minerals (think lead, arsenic, and sodium), and almost all microorganisms and large organic contaminants, including PFAS.

Most of the residential RO units on the market are designed to fit under kitchen sinks and consist of at least four cartridges: sediment filter, carbon filter, RO membrane, and post filter. The cartridges are typically manifolded together. The system also comes with a two- to three-gallon pressure tank to store the treated water and release it through a separate faucet mounted on the sink surface.

Countertop RO units are also available and can either be attached to the sink faucet or come with a carafe into which tap water is poured. Water from this carafe is pumped through the

membrane, and the permeate is collected in another carafe. This unit does not require proximity to a faucet and can be placed anywhere an electrical outlet is available.

For institutional, commercial, and industrial uses, RO is the primary technology for treating water for such diverse applications as boiler and cooling tower feed, product rinsing, pharmaceutical and semiconductor manufacturing, and seawater desalting. RO has become the most widely used technology for removing salts from water supplies.

The Mechanism

Although RO has been a key treatment technology for over 60 years, it is still surrounded by misunderstanding and mystery. This is partially the result of a lack of agreement on the actual mechanism of salt rejection. The most widely accepted theory is that the movement of salts through the membrane is based on concentration gradient, the difference between the salts concentration on the feed side of the membrane and the permeate side.

Meanwhile, the passage of water through the membrane is a function of water pressure. The purified water wins the race. The behavior of this technology includes examples that defy this explanation, however, hence the lack of agreement.

A recent theory considers friction between salt ions, water, and the membrane polymer atoms as the mechanism—another attempt to explain the mystery.

The removal of non-ionic contaminants (nonpolar organics, microorganisms, and other suspended solids) is strictly filtration; what's too big to pass through the membrane pores is held

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back. To further complicate matters, some experts claim that RO membranes don't actually have pores.

The Shortcomings

What removal claims *cannot* be made about reverse osmosis?

Since the rejection of non-ionic dissolved materials is based on size exclusion, what size contaminants will not be removed? Because the size of organic molecules is related to shape as well as molecular weight, the membrane industry has settled on the conclusion that any dissolved organic molecule with a molecular weight below 150 atomic mass units, or daltons, will likely pass through the membrane.

Microorganism removal is somewhat controversial. Whereas all bacteria are large enough to be rejected, because they are viable, or alive, many experts believe they can grow through a membrane. This appears to happen only if water sits stagnant on the feed side of the membrane, which allows the bacteria to attach to the membrane and multiply. Moving water does not appear to suffer from "grow through."

In general, because of viruses' small size and ability to grow inside bacteria, complete virus removal is not possible with RO. Disinfection is necessary to guarantee treated water contains a minimal concentration of microorganisms.

RO System Design

Let's say your primary interest is the design of a system to treat a water supply. How can this membrane be incorporated into a complete system to give you the quantity and quality of water you need?

Although membrane elements are available in four basic configurations (spiral, tubular, plate and frame, and hollow fiber), the overwhelming RO device configuration used in water purification is spiral. There are at least eight U.S. manufacturers of these membranes, all of high quality and competitively priced. Each manufacturer may have several models, each with special characteristics.

Once you have selected a particular spiral RO membrane, what do you need to know to design a treatment system?

It is important to understand the factors that influence RO system design. Here are some:

- Feed-water analysis.
- Membrane properties.
- Water temperature.
- Pump pressure.
- Flow rate.
- System recovery.

Your ability to adjust the feed-water chemistry is limited to the removal of slightly soluble salts such as iron and silica, but you must work with what you have. Adjusting the water temperature is usually very expensive, but this variable can affect membrane production rate, as will pump pressure and system recovery.

System Design Training

Where can you learn about RO system design? The 2023 Water Quality Association Convention & Exposition in Las Vegas will offer the Commercial/Industrial RO Sizing Workshop on April 17.

This workshop utilizes a problem-solving approach to teach the design fundamentals of RO systems. Participants sit in groups of four to six people and are provided with the calculations appropriate to develop the system design. An application is presented, and participants work together to examine the effect of influence factors on system design. As many as nine problems are presented, examining such variables as the effect of system recovery on permeate quality and the effect of temperature on permeate production flow rate. The problem offerings include seawater desalination and wastewater treatment.

A separate registration is required for this workshop. (<https://convention.wqa.org/pre-convention-sessions/ro-workshop/>)

Closing Thoughts

The role of acceptable quality water in sustaining life on this planet is widely recognized; however, what may be less clear are the looming crises of water quantity and quality.

Global warming has been linked to such weather-related catastrophes as hurricanes, wildfires, tornadoes, drought, and floods. These are severely affecting both the availability and quality of water supplies. More waterborne contaminants are being identified, and the increasing global population means the fixed quantity of water on this planet will become more and more contaminated.

We must employ increasingly innovative technologies to process all available sources of water—rainwater, storm water, humidity, industrial and municipal wastewater, etc.—and reverse osmosis is, and will continue to be, one of the best. **WCP**

About the author

♦ Peter Cartwright entered the water-purification and wastewater-treatment industry in 1974 and has had his own consulting engineering firm since 1980. He has a degree in chemical engineering from the University of Minnesota and is a registered professional engineer in that state. He has authored over 300 articles, written several book chapters, presented over 300 lectures in conferences around the world, and is the recipient of several patents. Cartwright is a recipient of both the Award of Merit and Lifetime Member Award from the Water Quality Association and is the technical consultant for the Canadian Water Quality Association. He was the 2016 McElhiney Distinguished Lecturer for the National Ground Water Research and Educational Foundation and gave over 35 lectures throughout the world on groundwater contaminant mitigation. Cartwright can be reached via email at peterscartwright@gmail.com, or visit his website, www.cartwright-consulting.com.



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Tips for Selecting Water Well Drills for Better Return on Investment

While many people consider the cheapest option to be the simplest answer, when selecting a water well drill, the upfront cost should never be the only deciding factor. A drill that achieves a high return on investment (ROI) will withstand challenging soil conditions time and time again, and be backed by quality support from its manufacturer. Before making a purchase, consider environmental conditions, drill quality, and manufacturer service.

Location

Start by determining the soil conditions the drill will encounter. Water well drillers face major expenses when drills can't meet the challenges of a project's location. For example, pulling a poorly manufactured drill over rough terrain can damage the equipment, resulting in delays and costly repairs.

Beyond drill quality, the drill type—whether mechanical or hydraulic—should be suited for the soil conditions it will most frequently work in.

Mechanical drills provide the necessary power and versatility for drilling in sand, clay, and loamy soils. These machines typically drill to depths of 100 feet to 200 feet, tackling the scope of most geotechnical and water well projects. Mechanical drills have few moving parts, making them easier for less-experienced drillers to operate while minimizing the risk of accidental damage. Additionally, mechanical drills tend to be lightweight and portable, so one or two individuals can easily load one onto the back of a truck or utility vehicle and unload it, allowing the drill to access more challenging locations.

Mechanical drills, however, are not suited for every project. To drill deeper and power through hard rock, a hydraulic drill

should be used. These machines achieve depths of 300 feet to 400 feet and are generally the go-to for crews that consistently drill deeper than 150 feet. To generate as much as 5,000 pounds of push-down force in rugged rock formations, look for a drill rig with an anchoring option and a bypass flow switch. With these added capabilities, crews can more efficiently reach clean water.

For transportation purposes, consider whether the drill will benefit from being mounted on a trailer. Although trailer-mounted models generally cost a bit more than standard hydraulic units, they provide a simple and reliable transportation solution. Some trailer-mounted rigs include space for hauling drill pipes and other equipment. Additionally, trailer-mounted drills are typically quicker to set up than their free-standing counterparts.

Construction

Drills from different manufacturers often appear quite similar. However, a closer look will help determine if a unit is built to last. Some manufacturers entice customers with low prices but avoid discussing quality. When calculating ROI, keep in mind that low-quality drills typically have shorter service lives and little to no resale value compared to higher-quality models.

Look for heavy-duty, welded-steel frames and thick drill pipes, for example, to ensure the drill can withstand challenging conditions. Some manufacturers cut corners by using thinner steel. This can cause the frame to bend or twist while driving, or wear prematurely due to corrosion in hot, humid climates. In addition, look for manufacturers that use drill pipe two inches in diameter and connections made of heat-treated alloy steel. Lower-quality drills often use 3/4-inch or one-inch pipes intended for less intense applications.



A mechanical rig can use rugged M250 drill pipe to efficiently reach 200-foot depths.

Drills that incorporate features to simplify maintenance make extending service life easier. For example, an easily accessible adjustment screw and locking nut minimize downtime when removing slack from the drive chain. Conveniently located greasing points also save a significant amount of time during routine greasing and maintenance checks. If maintained properly, a quality drill can last from five years to 20 years.

Support

Trust takes years to build and only seconds to lose. A reputable manufacturer wants customers to succeed and has a track record to prove it. The last situation a drill crew needs is a project standstill with no one to back up the crew. Look for manufacturers that provide training manuals, videos, and 24/7 technical support. Some manufacturers go so far as to offer training sessions at their facilities, which is a great way for inexperienced drillers to gain hands-on experience before beginning a project.

Remember, even quality drills will need replacement parts. To prevent downtime, choose a manufacturer that keeps replacement parts in stock and offers fast delivery.

Finally, take a close look at the manufacturer's warranty. One of the best ways to determine a manufacturer's confidence in its products—and its commitment to service and support—is by reviewing its warranty policies.

Once research is complete, start crunching the numbers. Given the work location and plans for the drill, determine if saving a few dollars today will pay off in the long run. But remember, getting the most drill for the dollar goes beyond the initial price tag. **WCP**



A drill with a simple hydraulic system can have pullback force of 2,500 pounds and push-down forces adjustable up to 2,500 pounds.



Hydraulic drilling units handle the toughest drilling projects and can operate in sand, clay, and hard rock formations.

About the author

As president of Little Beaver and Lone Star Drills, **Joe Haynes** works with a team of engineers to develop digging and drilling solutions, including earth drills, mini trenchers, water well drills, and horizontal boring kits. He has more than four decades of experience in the drilling industry and is committed to providing long-lasting solutions to customers around the world.



About the company

Lone Star Drills are innovative additions to the Little Beaver family of products that are designed to be a convenient, powerful solution in areas with minimal resources for transportation and operation. Twelve models are available, and they are ideal for use in a variety of applications, including water well drilling, soil sampling, geotechnical testing, and auger drilling. For more information, contact Lone Star Drills at sales@littlebeaver.com or www.lonestardrills.com.

Water Softener Evaluation Under NSF/ANSI 44

The point-of-use (POU) and point-of-entry (POE) water treatment industry considers water softeners to be a key element of its overall water solutions portfolio because of the value they provide for end-users with hard water. In many areas of North America and beyond, hard water is common, especially in certain regions such as the Great Lakes region. Water softeners are also highly engineered pieces of equipment, designed and constructed to provide end-users with years of reliable and efficient service.

A holistic evaluation of multiple aspects of water softeners is offered under NSF/ANSI 44 Residential Cation Exchange Water Softeners, allowing manufacturers, distributors, end-users, and regulators to be confident the equipment they're using conforms to the standard.

A Standard for Residential Softeners

There are applications for water softeners in residential, commercial, and industrial settings. The scope of NSF/ANSI 44 specifically covers residential applications, so it is important to clearly define "residential." NSF/ANSI 44 defines a residential softener as a regenerable cation exchange system intended for residential use with conventional plumbing fittings not exceeding nominal pipe size of 1.25 inches. Under this definition, any softener with an inlet exceeding 1.25 inches is not considered residential and falls outside the scope of the standard. Note that the definition is not related to resin tank size, amount of cation exchange resin, or system salt settings. It is based solely on the inlet size.

Testing Under the Standard

Figure 1 summarizes the testing requirements of NSF/ANSI 44. Material extraction testing is required to establish that contaminants do not leach from the softener at concentrations of toxicological concern. Structural integrity tests include 100,000 cyclic and 15-minute hydrostatic evaluations to establish the long-term durability of the system, as well as its resistance to pressure spikes. Pressure-drop testing confirms that the softener will not cause a drop of more than 15 pounds per square inch (psi) in line pressure when operated at the manufacturer's rated service flow.

Capacity of the softener is based on specific salt settings and determined by testing at half of the manufacturer's rated service flow. The feed water for this testing has a hardness of 20 ± 2 grains per gallon. The standard requires capacity testing at the lowest and highest salt settings, and the setting closest to

REQUIREMENT	TEST DESCRIPTION
Material safety	Extraction testing with toxicological evaluation of any contaminants detected.
Structural integrity	100,000 cyclic and 15-minute hydrostatic pressure testing.
Pressure drop	Differential pressure between inlet and outlet may not exceed 15 psi at rated service flow.
Exchange capacity	Challenge testing at half of rated service flow with feed water of 20 grains per gallon; endpoint when treated water reaches 1 grain per gallon.
Rinse effectiveness	Softened water must not exceed 100 mg/L chloride after regeneration.
Softening performance	Soft water must be produced at rated service flow for 10 minutes after regeneration.
Accuracy of the brine system	Amount of salt used for regeneration must be within 15 percent of nominal salt setting.

Figure 1: NSF/ANSI 44 Test Descriptions

the midpoint of the range of salt settings. Interpolation can be used to determine capacity for other non-tested salt settings. Extrapolation beyond the tested range is not permitted by the standard, so testing at the low and high salt settings is critical.

Capacity tests start by first regenerating with a precisely measured amount of saturated brine. Measured saturated brine is used instead of the softener's actual brine system to reduce variation in the amount of regenerant salt from the intended salt setting, which can cause variation in the tested capacity. Breakthrough of 1 grain per gallon in the softened water defines the endpoint of the test.

The standard also accounts for hardness leakage by requiring measurement of the hardness in the softened water throughout the test. The test is run multiple times; three successive runs within 10 percent of the average of the three runs is required.

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The average capacity value from these three runs is considered the official capacity at that salt setting.

The amount of residual chloride in the softened water is measured after regeneration. The net increase in chloride concentration from the softener may not exceed 100 milligrams per liter (mg/L). This confirms that the rinse is sufficient to rid the softened water of excess salt.

A softening performance test is also required. For this test, the softener is regenerated at the lowest salt setting and operated at the manufacturer's rated service flow. Samples of product water are taken each minute for 10 minutes, and the hardness of the water may not exceed 1 grain per gallon for any of these samples. This requirement ensures that the softener is being regenerated to effectively treat a minimum amount of water without excessive leakage at the rated service flow.

The accuracy of the brine system must also be tested. This testing is conducted at the lowest and highest salt settings, and the setting closest to the midpoint of the range. It requires placing the brine tank on a scale and weighing it before and after regenerations to determine the amount of salt used. The test must be run multiple times, and three successive runs within 15 percent of the nominal salt setting must be achieved.

For example, a successful test of a 10-pound salt setting would require the weight of the brine tank to decrease by 8.5 pounds to 11.5 pounds after each regeneration for a series of three regenerations. There is an alternate procedure involving calculations based on saturated brine that may be used for time-controlled brine systems.

Softener Efficiency

Water softener efficiency can be established for demand-initiated regeneration (DIR) water softeners, but not for other softeners. Efficiency is based on two factors:

- 1. The hardness capacity per amount of regenerant salt.
- 2. The capacity per volume of regenerant water.

More-efficient softeners require less salt and regenerant water to achieve the same amount of softening capacity compared to less-efficient softeners. Although efficiency is optional according to the standard, it may be required by state or local regulations.

Efficiency varies with the amount of salt used for regeneration. The higher the salt dosage, the lower the salt efficiency. There are diminishing returns in terms of softening capacity for regenerating with more and more salt. Ultimately, there is a saturation point at which additional salt used in regeneration will not achieve any more softening capacity and will simply be rinsed out of the system during regeneration. For this reason, efficiency ratings are always associated with specific salt settings.

Efficiency is calculated from data measured and recorded during capacity testing. The minimum requirements for softeners to be considered efficient are included in Figure 2. A softener must achieve the criteria related to both salt and water at a given salt setting to be efficiency rated. Also, any efficiency specifications or statements in the product literature or advertising must refer to the salt setting at which the efficiency was achieved. It is possible—and actually likely—that a softener can be efficiency

PARAMETER	EFFICIENCY REQUIREMENT
Salt efficiency	At least 3,350 grains of capacity per pound of regenerant salt.
Water efficiency	At least 1,000 grains of capacity per 5 gallons of regeneration water.

Figure 2: NSF/ANSI 44 Efficiency Requirements for DIR Softeners Only

rated at certain salt settings but not at others. Of note: California has a more stringent requirement for salt efficiency ratings than does Standard 44, requiring at least 4,000 grains of capacity per pound of regenerant salt.

NSF/ANSI 44 Includes Conformance by Calculation

The standard includes procedures to calculate pressure drop, capacity, and efficiency for softeners that are similar to the tested model but not actually tested themselves. There are specific requirements for softeners to be considered similar, including:

- Identical control valve.
- Identical distributor (length of distributor tube can vary with size of resin tank).
- Limitations regarding:
 - » Variation in cation exchange resin specifications.
 - » Amount of resin.
 - » Size of resin tank.
 - » Regeneration volumes.
 - » Flow rates.
 - » Salt dosages.

Using this approach, a family of softeners built with the same control valve but varying in tank size and media volume can be evaluated to the standard based on testing one or a few of them. Formulas included in the standard are used to calculate pressure drop, capacity, and efficiency for the non-tested models.

All Stakeholders Benefit from Thorough Evaluation

Testing all relevant aspects of water softeners is required by NSF/ANSI 44, including material safety, structural integrity, softening capacity, and accuracy of the brine system. The result is that a variety of tests is required, each one designed to evaluate different aspects of the softener. Evaluation of these aspects provides confidence in the functionality of the equipment for end-users, manufacturers, distributors, and regulators. WCP

About the author

♦ Rick Andrew is NSF's director of global business development, water systems. Previously, he served as general manager of NSF's Drinking Water Treatment Units (POU/POE), ERS (Protocols), and Biosafety Cabinetry Programs. Andrew has a bachelor's degree in chemistry and an MBA from the University of Michigan. He can be reached at 1-800-NSF-MARK or by email at Andrew@nsf.org.



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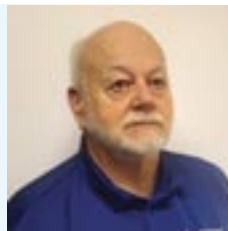
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Founded in 1983 by Darrell Weeter, FVS, Inc. prides itself on providing the highest-quality home care products and services and after-sales care to its customers. The organization has decades of experience developing products that enhance customers' lives through a cleaner, healthier home. The engineering, research and development, and executive staff have designed and produced products that specifically target and outperform the competition in removing dirt, dust, pollen, dust mites, odors, and toxic chemicals from homes. As a family-owned company, FVS, Inc. is invested in providing customers with good water- and air-quality products.

FVS Inc. services all of the United States and Canada and carries the Oxidize It Laundry System, AeroPure medical-grade room air cleaners, EnviroBreeze stainless steel lifetime HVAC filter, and laser particle counters used to test particles present in indoor air.

Weeter has decades of experience in the water-treatment industry. He studied business marketing in college and opened FVS in 1983. In 1986, Weeter incorporated FVS as a distribution company and became vice president of HMI Industries in 1987. In 2000, he became president of HMI and was responsible for handling the business in North and South America. He also became chief executive of FVS, Inc. the same year. In 2005, he assumed the role of full-time CEO and president of FVS, Inc. in order to develop product lines such as Filtrapor, AeroPure, and Oxidize It.

Benefits of Oxidize It

As one of FVS, Inc.'s flagship products, Oxidize It treats the water for washing machines so there is no need to use soap, fabric softener, or hot water; it also destroys bacteria and viruses 3,000 times faster than bleach and is environment and allergy friendly. Oxidize It provides several benefits for in-home use—it can

even be used to wash meats and vegetables (the ozone works to eliminate *E. coli* and *Salmonella*). Oxidize It can also "save the average family \$677 a year from not using soap, fabric softener, and hot water," Weeter said.

FVS, Inc. distributes Oxidize It alongside its AeroPure product line. The AeroPure line focuses on equipment and filters that improve the air quality within homes. The intention behind offering both water-treatment products and air products is simple. Weeter explained, "Since water and air are two things that people need to live on a day-to-day basis, offering air products with water-treatment products to customers helps add value to the consumer." Customers can expect whole-home solutions from FVS to improve their water treatment and air quality.

The Science Behind Oxidize It

The Oxidize It system uses ozone, which has been found to effectively remove stains from laundry. Utilizing an oxidation mechanism, ozone and hydroxyl (OH) radical, a breakdown product from ozone and water, both work as oxidants.

Ozone operates as a superior antimicrobial agent that can even eliminate superbugs when used properly. It is also an economical laundry option because it works best in cold water, relaxing fabrics so that no softener is required and more water is thus extracted during the spin cycle. Drying time is shortened, and the life of your clothing and other fabrics is extended.

The method for cleaning by ozone in water is based on two reaction mechanisms, direct and indirect. The direct method occurs when ozone acts as the oxidizer to break chemical bonds. The indirect method involves ozone reacting with water to produce OH radicals that then oxidize chemical bonds. When ozone and OH radicals come in contact with soils and stains in laundry, they help break chemical bonds to release the stain or soil.

Ozone has shown to be considerably more effective at lower water temperatures due to its increased stability at such temperatures. Using it in cold water cycles saves the energy that would have been used to heat the water. When compared to hydrogen peroxide, ozone utilized in cotton preparation was able to obtain a Stensby degree of whiteness of 81 scoured samples, which was comparable to hydrogen peroxide. When compared to chlorine bleach, the levels of ozone present may not always be

high enough to offer the same level of bleaching stains. Ozone is color safe, and it can be used alone instead of bleach to disinfect fabrics.

Ozone provides three major benefits:

1. Economical: Using ozone would be economically friendly, as it could decrease the annual costs of water use and purchasing traditional washing agents.
2. Microbiological: Ozone has been shown to effectively control and eradicate microorganisms normally found in soiled laundry.
3. Environmental: The use of ozone for laundry is also environmentally friendly, as the strong oxidizing power of ozone and OH radicals initiates the conversion of most organic components of soiling materials into more-readily biodegradable byproducts.

FVS, Inc. and Weeter on the Water Industry

Like many companies within the water-treatment industry, FVS, Inc. has faced the increasing costs of raw materials, which makes efficient production challenging. However, they remain dedicated to "helping provide customers with good water- and air-quality products," Weeter said.

In the coming months and years, Weeter explained, FVS is looking toward "expanding sales operations on an international basis."

It also aims to use ozone technology in developing other products for the water-treatment industry. Weeter was also proud to announce that "2022 sales for Oxidize It were the best since the launch of Oxidize It in 2016," and he expects 2023 to exceed those numbers.

Weeter explained, "The industry is strong, and as many people become aware of the necessity of good water treatment for their health, more people will begin to invest in water-treatment appliances." He continued, "Water dealers, along with water publications, need to keep educating the consumers in order to increase the growth of the water industry." **WCP**

About the author

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There Is No Safe Level of Lead

There are many things in nature you may not necessarily want to tangle with (fear-inducing images of quicksand, venomous snakes, or tornadoes may be flashing through your mind's eye). Lead ought to be one of them. Lead is a potent, bioaccumulating neurotoxin with particularly damaging effects when ingested by children.¹ Sources of lead in the environment can include paint, dust and soil, consumer products, food, cosmetics, medicines, and drinking water.² In drinking water, lead is rarely found in significant quantities in natural sources but is instead primarily introduced through the corrosion of lead-containing plumbing materials, as illustrated in Figure 1. Accordingly, lead pipe awareness is critical for public health protection.



Figure 1. Sources of lead in drinking water. Drawn using Biorender, modeled after the EPA infographic.³

To address the dangers posed by lead in drinking water, the U.S. Environmental Protection Agency (EPA) established the Lead and Copper Rule (LCR) in 1991. The LCR has since undergone multiple revisions and can be succinctly summarized in terms of four basic requirements:⁴

1. Require water suppliers to optimize their treatment systems to control corrosion in customers' plumbing.
2. Determine tap water levels of lead and copper for customers who have lead service lines or lead-based solder in their plumbing systems.
3. Rule out the source water as a source of significant lead levels.
4. If lead action levels are exceeded, require the suppliers to educate their customers about lead and, through public notices and public education programs, suggest actions customers can take to reduce their exposure to lead.

The LCR replaced the previous standard of 50 parts per billion at public water-treatment facilities with a lead action level of 15 parts per million (in more than 10 percent of customer taps sampled); instituted a maximum contaminant level goal of zero; and established a treatment technique to reduce corrosion of lead and copper in the distribution system.^{5,6} In 2000 and 2004, the EPA published minor revisions to the LCR aimed at streamlining monitoring and reporting.

Around the same time, Washington, D.C., experienced a crisis of lead in drinking water, triggered by a switch from free chlorine to chloramines, which altered the water chemistry and caused lead to leach into the water.⁷ This event helped to spur the 2007 "Short-Term Revisions to the Lead and Copper Rule," which sought to enhance LCR implementation in monitoring, treatment, customer awareness, and lead service line replacement.⁵ The 2014 water crisis in Flint, Michigan, again catapulted lead into the public domain after a switch in source waters increased water corrosivity and lead leached into the system. Subsequently, the EPA adopted the long-term revisions to the LCR in 2021.⁵

The long-term revisions included additional requirements for tap water sampling and testing, corrosion control, public outreach, and continued replacement of lead service lines when the action level is exceeded. The revisions maintained the 15 parts per billion (ppb) action level, with responses to exceedances varying by size of the system and corrosion-control practices. For example, if a large system exceeds the action level, it is required to maintain optimized corrosion control, and if corrosion control is already in place, the system must do the following:

1. Notify and educate the public.
2. Monitor source water and water quality parameters.
3. Begin replacing lead service lines.

The 2021 LCR revisions also established a lead trigger level of 10 ppb, the lowest level that can be reliably measured. Note that neither the action level nor the trigger level constitutes a health-based maximum contaminant level. Instead, the trigger level aims to "help water systems prioritize actions to control lead prior to an action level-exceedance (and reduce the likelihood of an exceedance)".⁸ Figure 2 illustrates this approach.

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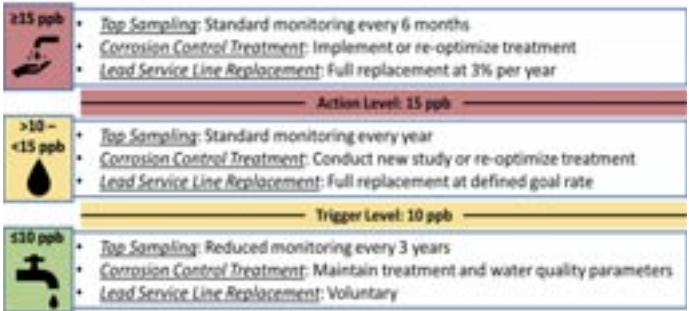


Figure 2. Lead concentration thresholds under the revised LCR. All concentrations are the 90th percentile level of tap water samples. Systems demonstrating less than 10 ppb for a mandatory three-year annual monitoring period after the LCR revisions may revert to the reduced monitoring every three years. Modified after Arnold and Rosenfeldt (2022).⁹

As part of the LCR revisions, water systems are required to prepare and maintain an inventory of service line materials by October 2024.¹⁰ In 1986, Congress prohibited the use of lead pipes, pipe fittings, and fixtures. However, widespread use prior to the ban means that an estimated 6.3 million to 9.3 million homes, in addition to other buildings with lead-containing solder or faucets, may still be served by lead service lines.⁸ Estimates of the number of lead service pipes in the United States are shown in Figure 3.



Figure 3. Lead service lines in the U.S., as posted on the White House Twitter account on June 30, 2021.

Lead is released from plumbing materials through corrosion, or the electrochemical interactions between metal surfaces and water, causing the release of oxidized metal. Scale naturally builds up on metal surfaces and can include an array of lead-based compounds, such as lead carbonates and lead oxides. Water-quality parameters (e.g., pH, alkalinity, oxidation-reduction potential, dissolved inorganic carbon, and corrosion inhibitors) influence lead corrosion, the formation and character of scale, and, ultimately, the release of lead into the water.¹¹ To reduce the

risk of lead dissolution, corrosion control is commonly implemented in water systems.

Corrosion-control treatments differ with water system size. Phosphate-based materials (containing orthophosphate, PO_4^{3-}) are most commonly used for lead-corrosion control, as they bind divalent lead, keeping it in the solid form rather than releasing the dissolved metal into the water. Hence, lead is sequestered in the piping system rather than released into the drinking water, where it poses an acute or chronic health risk. Target orthophosphate residual levels at the tap are often approximately one to three milligrams per liter as PO_4 , although higher levels may be used in higher lead risk scenarios. The EPA offers guidance to assist in selecting appropriate corrosion-control treatment strategies.¹¹

Beyond utility-scale responses in the form of corrosion control and lead service line replacement, point-of-use (POU) treatments are also available for controlling lead levels in drinking water. In selecting a POU option, consumers should look for technologies with accredited third-party certification such as NSF/ANSI 53 for lead removal using POU filters (and NSF/ANSI 42 for particulate removal).¹² By implementing an integrated portfolio of lead-mitigation approaches, including at scales ranging from POU to treatment facility to municipal, state, and national mapping and lead-component replacement efforts, we can continue to reduce the dangerous health risks associated with lead ingestion.

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