The 77th Annual INTERNATIONAL WATER CONFERENCE®

NOVEMBER 6-10, 2016
SAN ANTONIO, TX USA
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CONFERENCE PROGRAM GUIDE

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INTERNATIONALWATERCONFERENCE®

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WELCOME TO THE IWC

On behalf of the Engineers' Society of Western Pennsylvania (ESWP), the IWC Executive Committee, and the IWC Advisory Council, I am proud to welcome you to the 77th Annual International Water Conference® (IWC) in the great city of San Antonio, TX. The IWC remains the premier source of technical information and training in the industrial water and wastewater business, spanning numerous industrial sectors, and addressing today's most relevant technical topics.

As always you will find our technical program filled with current hot topics in the industrial water and wastewater treatment world including fluidized gas desulfurization wastewater, industrial wastewater treatment, water management and reuse, zero liquid discharge systems, mine water treatment strategies, and produced water treatment for the oil and gas industry, in addition to more traditional technical areas such as ion exchange, cooling water treatment, steam generator chemistry, and membrane treatment.

This year in addition to the printed program we are excited to provide our first digital app to help you navigate your way through the conference. You'll find download instructions within this printed program, at the registration desk, and at other key locations. I'd like to thank Mike Gaetano for his work in making the app a reality. We welcome your feedback on it.

Our technical program is the heart and soul of our conference. Its unique format includes peer review and prepared discussions for virtually every paper presented and reflects our commitment to ensuring that sharing and discussion of technical information is the primary focus of our conference. I'd like to thank this year's Technical Program Chairperson, Mike Sheedy, for all of his hard work in coordinating this year's program. This is one of the most time consuming positions on the IWC Executive Committee and Mike has done an excellent job in developing the program and coordinating with all of this year's Session Chairs, Discussion Leaders, Authors, and Discussers. A big thanks to all of those folks who have had a role in developing this year's technical program for their willingness to share their time and knowledge of the industry with all of us.

Our conference also offers the opportunity for you to gain more in-depth expertise by attending 4-hour training sessions presented by experts in the field and covering a wide-range of topics for beginner and experienced level water and wastewater treatment professionals. This year we are pleased to offer more than 22 different workshop opportunities for you to expand your knowledge base and earn continuing education credits. I'd like to thank Patricia Scroggin for her hard work in putting together a great set of courses for us this year. The workshops are held post conference on Wednesday afternoon and Thursday. Following the interest shown last year, we will also be offering 4 of the courses in basic water, ion exchange, reverse osmosis, and wet flue gas desulfurization pre-conference on Sunday afternoon, as well as post-conference. It is not too late to sign up for one or more of the workshops as registration will continue to be open at the registration desk throughout the conference.

General INFORMATION

We have again sold out our Exhibit Hall, which showcases the latest advancements in water and wastewater treatment. Be sure to take advantage of this great opportunity to meet with over 100 different company exhibitors and learn more about what's new in water and wastewater treatment. A big thank to all of our exhibitors for their continued support of the IWC. Lunch and other refreshments will be provided throughout the Hall during exhibit hours courtesy of our sponsors, so be sure to grab a bite to eat while you are networking.

In addition to a full technical program, we are fortunate to have Mr. Bill Kennedy, Strategic Engineering – Water Programs for Duke Energy, as our keynote speaker. We always strive to have our keynote address complement our technical program by being an educational and informative presentation on a highly relevant topic. We hope that you will join us for his keynote address on Monday morning and will find Mr. Kennedy's presentation both inspiring and informative.

A conference of this size does not get put together without the hard work of a lot of people. I want to thank the ESWP staff - Dave Teorsky, Taylor Bombalski, Michael Gaetano, and Cori Weber. The success and growth that the conference continues to experience each year is a direct result of all their hard work. You will always find at least one of them at the registration desk to answer any questions or provide any help that you might need during operating hours. I'd also like to recognize our dedicated IWC Executive Committee members for their commitment to making this year's conference a success. Every Executive Committee member is a volunteer and has spent countless hours coordinating sessions, exhibits, and workshops to make sure the conference runs smoothly. I would also like to thank the Advisory Council companies that offer their support, expertise, and guidance for maintaining a relevant and interesting program each year. The members of the Advisory Council are the key conference sponsors and allow us to provide coffee breaks, tote bags, the internet café and other items that contribute to a wonderful conference experience for all of us. If you have any interest in becoming a member of the Advisory Council, please see an ESWP staff member at the registration desk.

I hope that you enjoy this year's conference and value your chance to network with and learn from everyone that you meet here. I look forward to talking with many of you during our time in San Antonio. I, and the rest of the IWC Executive Committee, welcome your feedback which we will use to make improvements in future conferences.

The end of this 2016 International Water Conference marks the beginning of the 2017 IWC when we look forward to seeing you again in Orlando. Have a great conference!

Sincerely,

Debbie Bloom

Nalco Champion, an Ecolab Company

General Chair, 77th Annual International Water Conference

General INFORMATION

EXECUTIVE COMMITTEE

The International Water Conference® is sponsored by the Engineers' Society of Western Pennsylvania, a membership based, not-for-profit organization in Pittsburgh, PA. Members of ESWP create the IWC Executive Committee, who are top industry leaders. These ladies and gentlemen volunteer their time to help execute the conference year after year. ESWP extends a sincere thank you to Debbie Bloom for her leadership thru the planning year!

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The IWC Advisory Council is comprised of a group of companies that provide ongoing support for the planning of a successful conference. Membership is open to companies that have an interest in water & wastewater treatment, and are willing to make a commitment to participate in two meetings a year to plan the IWC. Ask the ESWP staff for details!

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ABOUT THE IWC

The IWC is the world's premier Conference for understanding and dealing with the technical and business challenges of industrial water treatment. IWC presents the latest in scientific advances and practical applications in this field, cutting across a wide range of industries and functional areas.

As the preeminent international technical forum in the field, the IWC will bring together almost 1,000 end users, researchers, practicing engineers, managers, educators, suppliers and contractors. It is dedicated to advancing new developments in the treatment, use and reuse of water for industrial and engineering purposes.

The IWC has always been a strong educational conference. Attendees come to learn about the latest applications available in the industrial water treatment industry, educate themselves in current technology and applications through attendance in IWC workshops, and network with their peers' active in water treatment.

WHAT MAKES THE IWC DIFFERENT?

All papers presented at the IWC are carefully peer reviewed for quality and to ensure no commercial aspect is evident. In addition to the broad educational and networking opportunities being offered, the IWC invites you to participate through our unique Prepared Discussion program. Each paper presentation at the conference is followed by a Prepared Discussion – a thoroughly considered, different perspective on the topic. This is followed by an open floor discussion when all audience members and presenters can fully interact - ask questions, seek clarification, and raise alternative viewpoints, in essence – learn more!

CONFERENCE PROCEEDINGS

All registered attendees (except Exhibit Only) will receive a CD containing the Official Conference Proceedings of the 77th Annual International Water Conference®. The CD will be direct mailed to you approximately 2 months following the conference.

CALL FOR PAPERS

To participate in the 2017 International Water Conference® as a presenter, please watch for the opening of the IWC Call for Papers. The Call for Papers is done exclusively on-line through the IWC home page at www.eswp.com/water. For more information on how to become active in the IWC as an Exhibitor, Advisory Council Company, Executive Committee member, please contact ESWP at 412-261-0170 ext. 10 or by e-mail at eswp@eswp.com.

AMERICANS WITH DISABILITIES ACT

The International Water Conference® and the Engineers' Society of Western Pennsylvania support the Americans with Disabilities Act (ADA), which prohibits discrimination against, and promotes public accessibility for, those with disabilities. We ask those requiring specific equipment or services as an attendee to contact the ESWP Conference Department and advise us of any such requirements in advance.

PROFESSIONAL DEVELOPMENT HOURS

Attendees are eligible to earn up to 20 Professional Development Hours (PDH) to satisfy Continuing Education requirements. Official confirmation of your attendance will be provided after the IWC, upon request. The Engineers' Society of Western Pennsylvania, sponsor of the IWC, is recognized as an Approved Provider by the Florida Board of Professional Engineers Bureau of Licensing and the New York State Board of Professional Licenses*. ESWP may grant Professional Development Hours to other states as well. *Special sign-in procedures are required for NY State PDH's

ATTENDEE RECEPTIONS

To help you enjoy your stay in San Antonio during the 2016 IWC, we have many special events and activities planned for you. Join your fellow conference attendees at the annual Get Acquainted Reception, held on Sunday in the Exhibit Hall to welcome you to

the Conference. Also, all registered attendees are welcome to attend the Receptions on Monday and Tuesday afternoons in the Exhibit Hall. Luncheon buffets are also provided Monday and Tuesday afternoons in the Exhibit Hall. Schedule time to visit the exhibits and enjoy lunch on us!

If your spouse is accompanying you to the IWC, please properly register him or her at the Registration Desk to gain admittance into these events.

LITERATURE TABLE

Our media partners are instrumental in helping promote the IWC. There is a table filled with literature from these partners as well as information about the area. Please take a moment to stop by and check it out!

SPOUSES' WELCOME BREAKFAST

For spouses who are traveling with conference registrants, the IWC will host a Welcome Breakfast on Monday, November 6 at the Hilton Hotel. You will be able to meet and network with other spouses to plan your own agenda of activities. Please complete registration form at the IWC Registration Desk. Advance registration is required.

IWC FUN RUN

Come join us for the 30th Annual IWC Fun Run! This event, sponsored by ResinTech, is open to all runners and walkers attending the conference and T-shirts will be awarded to all participants (limited quantity). Start time & place: Tuesday Morning, November 7 at 7:00 AM Sharp; meet in the hotel lobby at 6:45 AM. Distance: 3 miles – flat and easy course.

MERCHANDISE

IWC shirts and hats are available for sale! Pre-prints for (most) technical presentations are available at the Registration Desk. Pre-prints can be purchased for $5.00 per copy, or $35 per 1GB flash drive with all the available papers. Also, you can find copies of previous years' IWC Proceedings for $55 per volume.

NAME BADGE IDENTIFICATION

All registered conference attendees are asked to please wear your official IWC name badge at all times. Your official IWC name badge is your passport to the Technical Session, the Exhibit Hall, and International Water Conference® social functions. In addition, important local phone numbers have been printed on the back of your badge for your use. To avoid any confusion with access to the events, please refrain from personalizing your official IWC name badge with any stickers, ribbons, etc., not provided by the Registration Desk.

Please note that exhibit hall only registrations are only entitled to attend functions in the exhibit hall. They are not permitted to attend technical session or plenary sessions. This will be strictly enforced on site.

If you wish to upgrade your registration to a full-conference or one-day registration, please do so at the registration desk.

REGISTRATION LISTS

There will be a registration list of all those attending the conference available to view at the Registration Desk. A PDF version will also be available on the computer in the WebSpot to view and jump onto a USB.

An electronic version of the Registration List will be available at the Registration Desk the morning of Wednesday, November 2. It provides the names of all registered attendees in both Excel and comma-delimited text formats. There is a $25 fee, please provide a USB drive.

SOCIAL MEDIA

Keep up on the latest details of the conference by using #IWC16 and follow @EngSocWestPA on Twitter, or like us on Facebook: International Water Conference

TECHNOLOGY THAT HAS SHAPED OUR INDUSTRY – HISTORICAL REVIEWS FROM INDUSTRY EXPERTS

Monday, Nov. 7, 8:00–11:00 AM; Room: Salon I

IWC Rep: Mike Gottlieb, ResinTech Inc., West Berlin, NJ

Session Chair: Jim Summerfield, Dow Water & Process Solutions, Edina, MN

8:00 AM SESSION INTRODUCTION

Jim Summerfield, Dow Water & Process Solutions, Edina, MN

Our industry is replete with enabling technologies that have been through multi-generational product lifecycles and have survived the greatest scrutiny. These technologies remain foundational in our industry today and it's vital that we revisit these in order to appreciate the evolution of foundational technologies. This session will highlight only a few of the foundational technologies within our industry that have been through decades of advancements and improvements. We will provide historical reviews of ion exchange resins and steam turbines as well as the developmental life-cycle of all volatile treatment (AVT) for the mitigation of flow accelerated corrosion (FAC) in boilers and steam generators.

8:10 AM IWC 16-01: THE EVOLUTION AND DEVELOPMENT OF ION EXCHANGERS: HISTORICAL REVIEW & INDUSTRIAL PERSPECTIVES

Joseph Mandara and Carl Galletti, Resintech, West Berlin, NJ

The history of ion exchange can be traced back as far as biblical references. As scientific methods advanced, so did the understanding, development and application of ion exchange materials. This paper reviews the history and evolution of ion exchange materials from the perspective of how these developments were enabled by advances in related fields, and in turn, how improvements in ion exchange technology met the emerging needs of the water treatment industry.

8:50 AM IWC 16-02: A SHORT HISTORY OF STEAM TURBINES

James Bellows, James Bellows and Associates, Maitland, FL

Although steam turbine devices date back to antiquity, it was the inventions of Charles A. Parsons in the 1880's and 1890's that made steam turbines practical. In 1885, George Westinghouse purchased rights to Parson's patents and scaled up the turbines. The most important improvements will be traced. The increase in size and the changes in steam conditions over time will be developed. Deposition, corrosion and fatigue issues occurring through time are addressed.

10:00 AM IWC 16-03: ALL VOLATILE TREATMENT IN THE UTILITY POWER INDUSTRY – YESTERDAY & TODAY

Purusha Bonnin-Nartker and John Jevec, The Babcock & Wilcox Company, Barberton, OH

This paper provides a brief historical summary of the evolution of all volatile treatment (AVT) for fossil utility boilers and nuclear pressurized water reactor systems. Initially, the specifications were the same in both systems. To reduce iron transport, AVT in the fossil and nuclear systems began to diverge due to the differences in operating conditions and the materials of construction used for the steam generating systems. These differences will be discussed in the paper.

MAXIMIZING WASTEWATER REUSE FOR INDUSTRIAL USERS

Monday, Nov. 7, 8:00–11:00 AM; Room: Salon J

IWC Rep: Mike Soller, Bowen Engineering, Indianapolis, IN

Session Chair: Brad Biagini, Veolia Water Technologies, Moon Township, PA

Discussion Leader: Andrew Erickson, Burns & McDonnell, Kansas City, MO

8:00 AM **SESSION INTRODUCTION**

Brad Biagini, Veolia Water Technologies, Moon Township, PA

New federal regulations, increasing water scarcity, and corporate initiatives are some of the major drivers that are leading industrial facilities to evaluate wastewater reuse and recycle options. This session includes three papers: The Clean Water Act 316b rule related to overall facility water balance management, recycle/reuse best available technology selection, and the economic incentives and implications of wastewater reuse decisions. Wastewater reuse at a California power plant to maximize water recovery describing the design challenges and modifications associated with recirculated membrane reject. Lessons learned and full-scale design considerations that were obtained during a twelve-month integrated membrane system pilot on municipal wastewater treatment for reuse at a nearby chemical plant.

8:10 AM **IWC 16-04: SELECTING THE BEST PATH FORWARD: WATER TREATMENT OPTIMIZATION CASE STUDY**

Bryant Purse and Brad Buecker, Kiewit Engineering & Design CO., Lenexa, KS

The paper outlines a study that was performed to evaluate several makeup water treatment configurations for a new, natural gas fired, 2×1 combined cycle facility. Potential raw makeup sources were reclaimed water, potable water, or well water, with several possible treatment options for each source. The study incorporated design options for each source. The study incorporated design options for service water, demineralized water, cooling tower makeup, and cooling tower blowdown treatment systems. Because several possible design variations existed for each system, some configurations were discounted from final evaluation. This paper explores the rationale behind identifying problematic water constituents, evaluating treatment scenarios, and conducting a financial sensitivity analysis.

8:35 AM Discusser: Michael Doenges, Bowen Engineering, Indianopolis, IN

8:45 AM Floor Discussion & Closure

9:00 AM **IWC 16-05: INITIAL RESULTS FROM A WASTEWATER REVERSE OSMOSIS RECYCLE METHOD TO REDUCE REJECT VOLUME**

Julia Horn, Brian Clarke, and Brad Buecker, Kiewit Engineering and Design, Lenexa, KS; Jason Mitchell, U.S. Water Services, St. Michael, MN

A simple cycle peaking power plant under development in California was required to limit its annual water intake to 314 acre-feet. To meet this condition, innovative measures were taken during design to maximize water reuse. A wastewater system utilizing softening, silica reduction, and reverse osmosis (RO) reject recirculation was designed to provide 87% total system recovery. This paper describes the wastewater treatment system, discusses modeling of the RO dissolved solids concentration, and highlights design considerations.

9:25 AM Discusser: Tamim Popalzai, Advisian - WorleyParsons, Houston, TX

9:35 AM Floor Discussion & Closure

9:50 AM Break

10:10 AM **IWC 16-06: REUSE OF MUNICIPAL WASTEWATER AS INDUSTRIAL PLANT SUPPLY - PILOT TESTING FOR FULL-SCALE SYSTEM DESIGN**

Jason Stevens, Evoqua Water Technologies, Schaumburg, IL; Tracy Boswell, Evoqua Water Technologies, Cedar Park, TX

This paper will describe the treatment scheme, parameters tested, challenges encountered, lessons learned, and results obtained from a twelve month, twenty gallon per minute ultrafiltration and reverse osmosis pilot operating on the effluent from a municipal wastewater treatment plant.

10:35 AM Discusser: Hillary Kronebusch, Veolia Water Technologies, Pittsburgh, PA

10:45 AM Floor Discussion & Closure

11:00 AM Conclusion

INNOVATIVE ADVANCES IN ONLINE INSTRUMENTATION TO MEET STRINGENT INDUSTRY DEMANDS

Monday, Nov. 7, 8:00–11:00 AM; Room: Salon K/L

IWC Rep: Wayne Bernahl, W. Bernahl Enterprises Ltd., Elmhurst, IL

Session Chair: Brian Powers, HDR, Charlotte, NC

Discussion Leader: Tony Banweg, Nalco Champion, An Ecolab Company, Naperville, IL

8:00 AM **SESSION INTRODUCTION**

Brian Powers, HDR, Charlotte, NC

This session will provide exciting and innovative instrumentation developments to address specific industry gaps for reliable online monitoring of Selenium, Chloride, and Sulfate measurement to low ppb levels. In addition, this session will explore development of an EDI based technology for cation conductivity measurement as an O&M cost reduction to traditional resin based cation conductivity.

8:10 AM **IWC 16-07: CHEMICAL FREE DISINFECTION & DECHLORINATION TO PROTECT RO AND DEMINERALIZERTREATED BOILER MAKE UP**

Ytzhak Rozenberg, Atlantium Technologies, LTD., Isreal; Dennis Bitter, Atlantium Technologies, LTD., Sarasota, FL

Water quality is of paramount importance in power applications to ensure good product quality, efficient production levels and minimal energy costs. Water quality is highly affected by biofouling. A novel advanced UV technology, Hydro-Optic™ (HOD) UV, has demonstrated its ability to provide non-chemical disinfection and dechlorination of boiler and steam cycle water. The HOD UV technology has been evaluated by EPRI and various power facilities; demonstrating proven protection of RO membranes at reduced OPEX.

8:35 AM Discusser: Kristen Jenkins, Southern Research, Cartersville, GA

8:45 AM Floor Discussion & Closure

9:00 AM **IWC 16-08: ON-LINE PPB-LEVEL CHLORIDE AND SULFATE MEASUREMENT BY MICRO-CAPILLARY ELECTROPHORESIS**

Akash Trivedi and David Gray, METTLER TOLEDO Thornton, Inc., Billerica, MA

To control corrosion caused by chlorides and sulfates in power plants, cycle chemistry guidelines and turbine warranty requirements routinely specify very low ppb limits for these contaminants. Demonstrating compliance with these limits is a challenge with existing technologies. They either are coarse measurements or the costs of the instrument and its operation are prohibitive. This paper explores an alternative technology - MCE (on-line micro-capillary electrophoresis) - and its performance for trace-level chloride and sulfate measurements.

9:25 AM Discusser: Ken Kuruc, Hach, Medina, OH

9:45 AM Floor Discussion & Closure

10:10 AM **IWC 16-09: EDI VERSUS CONVENTIAL RESIN CATION EXCHANGES FOR CACE MEASUREMENT IN POWER PLANTS: AN ION CHROMATOGRAPHY STUDY**

Randy Turner, Swan Analytical USA , Wheeling, IL; Heini Maurer, Dr. Julia Gath, and Dr. Heinz Wagner, Swan Analytische Instrumente AG, Hinwil, Switzerland

The conductivity measurement after a cation exchanger was introduced soon after 1950 by Larson and Lane. This sensitive and highly reliable measuring principle has become the most commonly used analytical method in power plants. Reliable electro-deionization devices (EDI) provide the possibility of a substitution of the conventional cation exchange resin filled column by an EDI arrangement seems possible. This paper provides a description of such a dedicated device and a practical evaluation is discussed.

10:35 AM Discusser: Vickie Olsen, Honeywell Process Solutions, Sandy Springs, GA

10:45 AM Floor Discussion & Closure

11:00 AM Conclusion

PRODUCED WATER – DESIGN AND OPTIMIZATION

Monday, Nov. 7, 8:00–11:00 AM Room: Salon M

IWC Rep: Mike Ryder, Chester Engineers, Moon Township, PA

Session Chair: Greg Mandigo, Aquatech International Corporation, Hartland, WI

Discussion Leader: Tom Lawry, McKim & Creed, Sewickley, PA

8:00 AM **SESSION INTRODUCTION**

Greg Mandigo, Aquatech International Corporation, Hartland, WI

Produced water treatment technologies will play a vital role in the future development of the world's shale gas and heavy oil reserves. The steady rise in global energy consumption along with the simultaneous emphasis being placed on associated environmental impacts, will position water treatment technology at the center of resource development. The papers in this session will focus on innovative aspects of facility design as well as analytical techniques that can be used to optimize produced water treatment.

8:10 AM **IWC 16-10: TREATMENT OF UPSTREAM OIL & GAS WASTEWATERS PRIOR TO DISPOSAL INTO A CLASS IID WELL - MARCELLUS & UTICA SHALE PLAY**

Russ Huffmyer, McKim & Creed, Inc., Sewickley, PA; David Grottenthaler, Self-Source Solutions, McDonald, PA

In the upstream O&G sector, wastewater is generated during the drilling, completions, and production of gas and oil wells. This paper will discuss the treatment of these wastewater streams, prior to utilizing a Class IID disposal well. These wastewater streams from the different phases in the life of the well contain varying amounts of suspended solids and contamination that need to be managed to avoid damage to the formation in which the wastewaters are disposed.

8:35 AM Discusser: Jonathan Shimko, Tetra Tech, Inc., Pittsburgh, PA

8:45 AM Floor Discussion & Closure

9:00 AM IWC 16-11: USES OF WAC RESIN IN THE HYDROGEN FORM

Guy Mommaerts, IESCI, Elmira, ON Canada

Weak Acid Cation resins, in the sodium-form, have been used widely to soften high TDS water, like Produced Water. The characteristics of this resin, used in the hydrogen-form, differ greatly from when it is used in the sodium-form. This paper reviews the characteristics of WAC resin used in the Hydrogen-form in different applications. There is a big difference, in regeneration requirements, between using this resin for alkalinity removal and for hardness removal.

9:25 AM Discusser: Michael Dejak, Eco-Tec Inc., Calgary, AB, Canada

9:35 AM Floor Discussion & Closure

9:50 AM Break

10:10 AM IWC 16-12: IMPROVING ANALYTICAL TEST METHODS IN SAGD/CSS WATER STREAMS

Joe B. Bodeux, Baker Hughes, Bonnyville, AB Canada; René Bélanger, P. Eng., Baker Hughes, Sturgeon County, AB Canada; Stephen A. Wight, Baker Hughes, Fort McMurray, AB Canada

Steam-Assisted Gravity Drainage (SAGD) and Cyclic Steam Stimulation (CSS) facilities commonly face analytical challenges due to the unique water quality supplying the de-oiling equipment, Hot or Warm Lime Softeners (HLS/WLS) and ion exchange treatment systems. Important operational decisions and chemical usage rely on sound analytical laboratory test data. This paper discusses modifications to the analytical procedures related to silica analysis, oil-in-water content, chelated and free total hardness, and true alkalinity measurements.

10:35 AM Discusser: Chip Westaby, Turner Designs Hydrocarbon Instruments, Kirkwood, MO

10:45 AM Floor Discussion & Closure

11:00 AM Conclusion

KEYNOTE SESSION

Monday, Nov. 6, 11:00–12:00 Room: Salon K/L

Session Chair: Debbie Bloom, Nalco Champion, an Ecolab Company, Naperville, IL

The IWC Keynote Session is the official start to the 2016 conference. In addition to the presentation of the annual awards, including the IWC Award of Merit, and the Paul Cohen Award, we are pleased to have Mr. Bill Kennedy of Duke Energy Corporation as the Keynote Speaker of the conference.

Following the conclusion of the Keynote Session, enjoy lunch strolling thru the IWC Exhibit Hall and visit with the many exhibitors to extend the opportunity to learn and network!

The Annual Awards are presented to celebrate the following achievements in the water treatment industry. Awards are presented in the following three categories:

ANNUAL MERIT AWARD:

Each year, the International Water Conference® presents the Annual Merit Award to honor outstanding individuals in the field of industrial water technology. This year's Merit Award Winner is Colleen Layman.

PAUL COHEN AWARD:

As a memorial to Paul Cohen and his contributions to the power generation industry, the IWC is proud to recognize the authors of the most precise and innovative presentation in the field of power systems water technology that was presented at the 75th Annual IWC. Paul Cohen Award: This year, we honor James Bellows for his presentation of IWC 15-25, Chemical Processes in Steam Turbines.

JOSEPH A. LEVENDUSKY SCHOLARSHIP:

This year, Epicor Inc. donated $1,500 to two scholarship recipients, Brielle Cash and Stephanie Hicks who are furthering their education in water engineering.

KEYNOTE PRESENTATION


Bill Kennedy

Bill Kennedy is the manager of Strategic Engineering – Water Programs for Duke Energy. Bill's previous work experience includes 30 years of process engineering, design, startup and troubleshooting of various processes in the chemical industry. Bill holds a BS in Chemical Engineering from Virginia Tech and is registered as a professional engineer in a number of Mid-Atlantic States.

For the past several years, Bill has worked with the electric power generating industry as a consulting engineer for waste water treatment. Bill's efforts include commissioning and technical review of the design/construction/operation of nearly two dozen FGD waste water treatment systems, pilot testing and full scale implementation of multiple biological systems including fixed bed and suspended growth bioreactors, SBRs, constructed wetlands and vertical flow wetlands. Other current activities involve technical design review of a IGCC grey water treatment system utilizing evaporator/crystallizer technologies and ash basin dewatering.

Bill has also been involved on behalf of the electric power industry in methods development and data collection for FGD waste water analysis of trace metals and data collection efforts in support of the update to the Steam Electric Power Generating Effluent Guidelines.

RECENT ADVANCES IN REVERSE OSMOSIS TECHNOLOGY

Monday, Nov. 7, 1:15–5:00 PM; Room: Salon I

IWC Rep: Dennis McBride, Burns and McDonnell, Kansas City, MO

Session Chair: Jane Kucera, Nalco, An Ecolab Company, Naperville, IL

Discussion Leader: Denise Haukkala, The DOW Chemical Company, Houston, TX

1:15 PM **SESSION INTRODUCTION**

Jane Kucera, Nalco, An Ecolab Company, Naperville, IL

The first commercial reverse osmosis installation was initiated in 1965, at Coalinga, California. This system used relatively low productivity and high pressure, tubular, cellulose acetate membranes. In the 50 years since, there have been many improvements in the technology in terms of performance and the use of RO to tackle ever more challenging feed water sources. However, there are still some limitations to the use of RO, including the tendency for the membranes to foul and scale. This limits the application of the RO. For example, fouling and scaling can cap recovery which may result in a relatively high proportion of waste that in today's water stressed environment is not desirable. Hence, the focus of today's session is membrane fouling and recovery. Papers will discuss the impact of RO membrane fouling, and how to predict and monitor fouling, plus advanced methods to mitigate fouling. We will also cover novel methods for increasing recovery while minimizing fouling and scaling of the membranes.

1:25 PM **IWC 16-13: IMPROVING THE FOULING RESISTANCE OF REVERSE OSMOSIS ELEMENTS**

Guillem Gilabert-Oriol and Claudia Niewersch, Dow Chemical Iberica, Tarragona, Spain; Jon Johnson and Tina Arrowood, The Dow Chemical Company, Minneapolis, MN; Gerard Massons, Centre Tecnologic de la Quimica de Catalunya, Tarragona, Spain; Aikaterini Tsoutsoura and Veronica Garcia-Molina,, DOW Europe GmbH, Horgen, Switzerland; Yang Cheng, DOW Chemical(China) Invest Co., Shanghai, China

Biofouling in reverse osmosis occurs when bacteria settles in the element and starts building a biofilm. This paper highlights the performance of new generation of fouling resistant RO element under one of the most difficult fouling conditions, biofouling. Three separate experimental plants using new generation RO element in comparison to previous generations of existing fouling resistant products in order to demonstrate a reduction in cleaning frequency of 30-50%.

1:50 PM Discusser: Anne Bridgman, Canadian Water Technologies, Calgary, AB Canada

2:00 PM Authors Closure & Floor Discussion

2:05 PM **IWC 16-14: CLOSED CIRCUIT REVERSE OSMOSIS OF INDUSTRIAL WASTEWATER AT HIGH RECOVERY WITHOUT SCALING**

Richard Stover, Ph.D. and Michael Boyd, Desalitech, Newton, MA

A Midwest food processing company sought to purify wastewater with reverse osmosis (RO) for reuse within the facility. However, high levels of barium sulfate and silica precluded traditional RO. As a means to achieve maximum recovery rates and minimize brine waste without membrane scaling or fouling, the company tested semi-batch or closed circuit desalination (CCD) reverse osmosis. This paper illustrates the importance of CCD RO technology for high recovery and process reliability for wastewater reuse.

2:30 PM Discusser: Andrew Erickson, Burns & McDonnell, Kansas City, MO

2:40 PM Authors Closure & Floor Discussion

2:55 PM IWC 16-15: CORRELATING LASER NEPHELOMETRIC TECHNIQUES TO TRADITIONAL MONITORING OF SILT DENSITY INDEX IN RO

Ken Kuruc, Denton Slovacek, and Luke Johnson, Hach, Loveland, CO

Work has recently been performed demonstrating the efficacy of using a laser Nephelometer as a surrogate for traditional silt density index (SDI) readings. Placing the device on-line eliminates the need for user interface, providing that a good correlation can be identified between NTU (Nephelometric Turbidity Units) and SDI. This study will examine preliminary plant data along with laboratory analysis to make a connection between these two related yet different approaches.

3:30 PM Discusser: Kelle Zeiher, Garrett-Callahan, Burlingame, CA

3:40 PM Authors Closure & Floor Discussion

3:55 PM IWC 16-16: IS RO DATA NORMALIZATION TELLING US ANYTHING? (OTHER THAN WHAT WE ALREADY KNOW)

Jason Jacobsen, American Electric Power, Columbus, OH

Trends developed from normalized RO data are typically used to evaluate membrane performance and in establishing preventative maintenance. However, correlations have been observed between normalized data to feed temperatures, conductivity, etc. Data observed also shows normalized data recovery without offline cleanings, only changes in operating conditions, primarily temperatures. These observations have led to the question whether RO normalization alone is adequate to predict RO cleaning requirements and/or loss of performance.

4:20 PM Discusser: Steven Coker, Dow Water and Process Solutions, Lake Jackson, TX

4:30 PM: Authors Closure & Floor Discussion

4:45 PM Conclusion

IWC 16-RESERVE: HIGH RECOVERY REVERSE OSMOSIS SYSTEM WITH INTEGRATED SALT PRECIPITATION CYCLE FOR INDUSTRIAL WATER TREATMENT APPLICATIONS

Alex Drak, Ph.D., Roi Zaken, and Tomer Efrat, IDE Technologies, Kadima, Israel

The operation of conventional RO systems in industrial water treatment applications is not an easy task. These systems have several drawbacks that limit their use in industrial water treatment applications and, in some cases, even prevent them from becoming a feasible solution. Conventional systems might be limited when it is necessary to handle variable feed water quality and variable water recoveries, as well as at supersaturation conditions of sparingly soluble salts.

IWC 16-RESERVE: NEW ASD FEED SPACER GEOMETRY REDUCES POWER CONSUMPTION AND BIOACCUMULATION

Carsten Schellenber and Stefan Lehmann, Lanxess Deutschland GmbH, Bitterfeld, Germany; Alan D. Sharpe, Lanxess Sybron Chemicals, Inc., Birmingham, NJ

Reverse Osmosis (RO) technology is commonly employed in industrial water applications. This desalination technique is often considered energy intensive. Improvements in feed spacer geometry have been shown to reduce the overall RO system energy consumption, reducing the operational costs on the order of 2 -5%. Further, changes in feed spacer geometry have been shown to reduce the incidence of bioaccumulation, reducing cleaning frequency, and possibly improving membrane lifetime.

COAL FIRED POWER PLANT WASTEWATER ISSUES AND SOLUTIONS

Monday, Nov. 7, 1:15–5:00 PM; Room: Salon J

IWC Rep: Scott Quinlan, GAI Consultants, Inc., Cranberry Township, PA

Session Chair: Kristen Jenkins P.E., Southern Research, Cartersville, GA

Discussion Leader: Matt Roth, DOW Water & Process Solutions, Collegeville, PA

1:15 PM **SESSION INTRODUCTION**

Kristen Jenkins P.E., Southern Research, Cartersville, GA

Coal fired power plants are facing a number of water issues today, largely being driven by EPA's Effluent Limitation Guideline (ELG) and changing water quality standards. This session includes papers focusing on specific pollutant removals from FGD (boron), approaches to manage chloride in a no discharge scenario, ways to better manage FGD solids, and treatment of low volume wastes.

1:15 PM **IWC 16-17: INNOVATIVE SOLIDS SEPARATION AND DEWATERING OF FLUE GAS DESULFURIZATION (FGD) WASTEWATER TREATMENT**

Thomas Higgins, Ph.D., P.E., CH2M, Reston, VA; Dennis Fink, CH2M, Oakland, CA; Jeffrey Tudini, CH2M, Atlanta, GA

Simply focusing on flow reduction to reduce FGD wastewater treatment costs can minimize savings and environmental benefit; a significant cost of physical/chemical treatment stems from solids handling/dewatering. We present a pretreatment solids separation and dewatering system that separates larger FGD wastewater solids for direct landfilling. Fine solids are settled and dewatered in a reduced-size system. We show field testing and economic analysis comparing cost savings of flow reduction, this technology, and conventional solids-dewatering in a reduced-size system. We show field testing and economic analysis comparing cost savings of flow reduction, this technology, and conventional solids-dewatering systems.

1:40 PM Discusser: Charles Dyke, Advisian, Houston, TX

1:50 PM Authors Closure & Floor Discussion

2:05 PM **IWC 16-18: TARGETING CHLORIDE IN FGD WASTE STREAMS**

Ivan Cooper, Civil & Environmental Consultants, Inc., Charlotte, NC

A zero-discharge Midwest coal-fired power experienced chloride buildup in the FGD system feed. The original plan did not include an on-site landfill, so when the CCR was placed in this new landfill, the leachate caused chloride buildup and a plant water imbalance. This paper identifies techniques for tracking and managing chlorides in a zero discharge system, including an evaluation of options for managing the excess chlorides and flow.

2:30 PM Discusser: David Weakley II, GAI Consultants, Homestead, PA

2:40 PM Authors Closure & Floor Discussion

2:55 PM **IWC 16-19: TREATMENT OF NON-CHEMICAL METAL CLEANING WASTEWATER FOR POWER PLANTS**

Charles McCloskey, Evoqua Water Technologies, Schaumburg, IL

The new ELG regulations calls out the need for treatment of non-chemical metal cleaning wastes. This paper will discuss the sources of these wastewaters, the unique chemical constituents and challenges of treating to meet local discharge standards. Case histories of successful application of mobile treatment technologies will be provided. Guidance for future planning to handle this emerging application will also be discussed.

3:20 PM Discusser: Daniel Sampson, WorleyParsons, Vallejo, CA

3:30 PM Authors Closure & Floor Discussion

4:05 PM IWC 16-20: FROM POWER PLANT EFFLUENTS TO FLOWBACK & PRODUCED WATER TREATMENT - AN INNOVATIVE APPROACH TO BORON REMOVAL.

Jeff Easton, WesTech, Salt Lake City, UT

Boron is highly soluble and difficult to remove from water and wastewater streams. High concentrations of boron are found in power plant waste ponds as well as in flowback and produced water. Currently ion exchange or reverse osmosis can be effective for boron removal. However the unintended consequence and associated cost is significant de-mineralization of the treatment flow. This paper introduces an innovative and selective process for boron capture and residual sequestration by polymer adsorption.

4:30 PM Discusser: Shelley Wojciechowski, NRG, New Florence, PA

4:40 PM Authors Closure & Floor Discussion

IWC 16-RESERVE COAL: CASE STUDIES OF THE DETAILS NEEDED FOR SUCCESSFUL EFFLUENT LIMITATIONS GUIDELINES (ELG) AND COAL COMBUSTION RESIDUALS (CCR) COMPLIANCE STRATEGY AND DESIGN

Heyward Suber, P.E., CH2M, Atlanta, GA; Hal Davis, P.E., CH2M, Charlotte, NC; Thomas E. Higgins, Ph.D., P.E., CH2M, St. Augustine, FL

The Effluent Limitations Guidelines (ELGs), along with the Coal Combustion Residuals (CCR) Rule and local discharge limits, pose a significant compliance challenge for many power plants. To establish a plant-specific compliance strategy that minimizes cost and risk, it is critical to examine in detail the requirements and the technologies available to meet those requirements. This paper focuses on case studies and discusses specific approaches in the following areas: obtaining ELG compliance deadlines in permit negotiations, building an integrated schedule for CCR Rule and ELG compliance, forecasting upcoming limits based on water quality-based effluent limits (WQBELs) for use in setting the treatment system design basis, planning for source segregation necessary to comply with the ELG, and selecting and designing treatment systems to meet strict limits.

COOLING WATER MICROBIOLOGICAL CONTROL ALTERNATIVES

Monday, Nov. 7, 1:15–5:00 PM; Room: Salon M

IWC Rep: Paul Puckorius, Puckorius & Associates, Inc./Water Training Serv., Westminster, CO

Session Chair: Michele Funk, Bechtel Infrastructure and Power Corp., Frederick, MD

Discussion Leader: Charles Kuhfeldt, Athlon Solutions, Geismar, LA

1:15 PM **SESSION INTRODUCTION**

Michele Funk, Bechtel Infrastructure and Power Corp., Frederick, MD

With the ever increasing scarcity of water, cooling water systems must be designed using challenging water sources such as gray water. Traditional oxidizing biocides such as chlorine gas and sodium hypochlorite treatment technologies may require expensive corrosion resistant material selection or may not be sufficient for effective control. The papers in this session will discuss alternatives and enhancements to traditional technologies in order to effectively control biofouling of cooling water systems.

1:25 PM **IWC 16-21: WATER CONSERVATION UTILIZING AN INNOVATIVE OXIDIZING MICROBICIDE PROGRAM**

Darrell Hartwick, Buckman, North Lancaster, ON Canada; Mazhar Warsi, Khurram Shahzad, and Jahangir Kalroo, Buckman Asia, Singapore

Monochloramine (MCA) has been used for decades in potable water but, limitations with its generation restricted its use in industrial plants. MCA selectively reacts with sulphur bonds within microbial proteins and this selectivity lowers the demand for MCA compared to other oxidizing biocides. MCA is used at several world-class fertilizer plants located in Asia for microbial control and was instrumental in improving water conservation by lowering bleed- off requirements.

1:50 PM Discusser: Orin Hollander, Holland Technologies, Inc., Jamison, PA

2:00 PM Authors Closure & Floor Discussion

2:15 PM **IWC 16-22: DETECTION, MANAGEMENT AND RESTORATION OF COOLING WATERS EXPERIENCING INLEAKAGE IN THE HYDROCARBON REFINING INDUSTRY**

Edward Beardwood, Solenis LLC, Wilmington, DE; Christopher Baron, Solenis LLC, Wilmington, DE

A novel approach to onsite, high purity generation of monochloramined amine, when applied to cooling waters, has revealed equivalent performance attributes as associated with chlorine dioxide applications for planktonic and sessile biological control. Process inleakage contaminates result in high consumption of conventional biocides due to the demand; however, only the biological activity present during inleakage upset qualifies as the monochloramine demand. This attribute allows for microbiological control under very stressful conditions, where-in corrosion rates, exchanger heat extraction rates and cooling tower heat rejection rates can be maintained within acceptable limits.

2:40 PM Discusser: Christopher Nalepa, Albemarle Corporation, Baton Rouge, LA

2:50 PM Authors Closure & Floor Discussion

3:05 PM Break

3:20 PM **IWC 16-23: REDUCTION ON WATER CONSUMPTION ON A COOLING TOWER WITH THE APPLICATION OF A NOVEL BIOCIDE**

Anderson Beber, Solenis LLC, São Paulo, SP Brazil

This paper shows the results of the application of a novel mild oxidizer on a large cooling tower at a power plant in Southern Brazil. This cooling tower utilizes grey water (tertiary treated domestic sewage) as make up. With the application of this technology, there was an improvement in both microbiological control and corrosion rates. Additionally, the plant was able to increase concentration cycles from an average of 4.5 up to 6.5, resulting in annual savings of over USD 400,000.

3:45 PM Discusser: HG Sanjay, Bechtel Corporation, Reston, VA

3:55 PM Authors Closure & Floor Discussion

4:10 PM **IWC 16-24: NON-OXIDIZING BIOCIDES FOR BIOFOULING CONTROL IN INDUSTRIAL WATER SYSTEMS**

Brian Corbin, Dow Microbial Control, Collegeville, PA

Effective microbial control is an important aspect of a successful water treatment program. Consequences of poor biological control include biofouling, reduced system efficiency, microbiologically influenced corrosion, and increased downtime. In this paper, we will discuss the value of non-oxidizing biocides and industry best practices in controlling biofouling across multiple applications. The paper will also discuss recent innovations in solid biocides and the numerous advantages over their liquid counterparts.

4:35 PM Discusser: Christopher Baron, ChemTreat, Newark, DE

4:45 PM Authors Closure & Floor Discussion

5:00 PM Conclusion

PRODUCED WATER CONDITIONING FOR THERMAL ENHANCED OIL RECOVERY SYSTEMS

Monday, Nov. 7, 1:15–5:00 PM; Room: Salon K/L

IWC Rep: Mike Sheedy, Eco-Tec, Pickering, ON, Canada

Session Chair: Ivan Morales, Devon Canada, Calgary, AB, Canada

Discussion Leader: Don Downey, Purolite Corporation, Paris, ON, Canada

1:15 PM **SESSION INTRODUCTION**

Ivan Morales, Devon Canada, Calgary, AB, Canada

Papers being presented will relay applicable knowledge to Evaporator (MVC) performance in a practical case study, coagulant selection for Lime Softening Process, Silica Management using case studies in cooling water, once through steam generators, evaporators, and geothermal surface equipment; and Membrane application in produced water systems at commercial scale.

1:25 PM **IWC 16-25: SILICA MANAGEMENT IN WATER TREATMENT – THE LAST FRONTIER**

Jasbir S. Gill, Nalco Champion, an Ecolab company, Naperville, IL

Silica control in applications such as cooling waters, boilers, evaporators, once through steam generators, membranes, and geothermal has eluded the water treatment experts for long time. Many times presence of silica has limited its use and reuse. The paper highlights the development of new silica inhibitor and its use by presenting case studies in many applications such as cooling waters, once through steam

generators, evaporators, and geothermal surface equipment and brine disposal wells.

1:50 PM Discusser: Kevin Drake, Drake Water Treatment Consulting, Calgary, AB Canada

2:00 PM Authors Closure & Floor Discussion

2:15 PM IWC 16-26: IMPACT OF PH ON SILICA REMOVAL USING MAGNESIUM OXIDE CHEMISTRY AT AN OIL & GAS WATER RECLAMATION FACILITY IN CALIFORNIA

John Korpiel and Kashi Banerjee, Veolia Water Technologies, Moon Township, PA; Lnsp Nagghappan, Veolia Water Technologies, Brea, CA; Bruce Bishop, Benoit Tranape, and Tracey Williams, Veolia Water Technologies, Waltham, MA; Harry Wojnar and Dwight Ferguson, Veolia North America, San Luis Obispo, CA

Magnesium oxide (MgO) is a proven and cost-effective chemical for silica removal in warm lime softening treatment of oil & gas industry produced waters. The impact of pH on MgO performance for silica removal is critical, especially in applications involving membrane filtration. This paper discusses the successful application and optimization of silica removal using MgO chemistry in conjunction with warm lime softening and ceramic ultrafiltration at an Oil & Gas Water Reclamation Facility in California.

2:40 PM Discusser: Rudy Tamayo, Solaris Management Consultants, Surrey, BC Canada

2:50 PM Authors Closure & Floor Discussion

3:05 PM Break

3:20 PM IWC 16-27: ZETA POTENTIAL AND COAGULANT PRE-SCREENING TEST METHOD OF PRODUCED WATER IN SAGD/CSS WATER

René Bélanger, P.Eng., Baker Hughes, Sturgeon County, AB Canada; Daniel Di Bon, P. Eng., Baker Hughes, Calgary, AB Canada; Edward J. Van Doorn, Ph. D., Baker Hughes, Blind Bay, BC Canada

Coagulants, reverse emulsion breakers, water clarifiers or cationic polymers play an integral role in the treatment of Produced Water in regards to de-oiling and Hot/Warm Lime Softener (HLS/WLS) processes of Steam-Assisted Gravity Drainage (SAGD) and Cyclic Steam Stimulation (CSS) heavy oil recovery processes. This paper describes an analytical test method used to quantitatively evaluate and rapidly pre-screen coagulants for secondary jar testing based on charge neutralization of de-oiled produced water versus product dosage.

3:45 PM Discusser: Chris Graham, Purolite, Calgary, AB Canada

3:55 PM Authors Closure & Floor Discussion

4:10 PM IWC 16-28: HIGH FLUX MEMBRANE FILTRATION FOR OIL WATER SEPARATION

James Peters, PPG Industries, Monroeville, PA

Environmental regulations and water scarcity have created a need for economical water treatments that allow for reuse. This paper will review a novel membrane with a unique composite single layer microstructure providing high flux, excellent separation capabilities and durability. The presentation will describe the intrinsic membrane properties, compare performance versus competitive membranes and then review a number of case studies from lab scale to commercial size filters on a variety of industrial wastewaters.

4:35 PM Discusser: Darrell Hartwick, Buckman, North Lancaster, ON Canada

4:45 PM Authors Closure & Floor Discussion

5:00 PM Conclusion

IWC 16-RESERVE: PRODUCED WATER TREATMENT TECHNOLOGIES FOR HYDRAULIC FRACTURING

Anne Wrobetz, EIT, Navigant Research, Boulder, Colorado

Produced water from hydraulic fracturing is a significant contributor to deep well injection volumes. Deep well injection has recently come into regulatory discourse due to a possible correlation with seismic activity, notably in the central and eastern United States (USGS, 2016). Produced water contains a variety of contamination, including high salts content, heavy metals, and radiation (Colorado, 2016). Many of these cannot be sufficiently addressed in municipal waste water treatment plants. Small, portable systems that utilize reverse osmosis and membrane technologies are becoming more popular to reduce water that must be either injected deep underground or transported to faraway treatment plants. Especially with the recent low price of oil, E&P companies must cut disposal costs in order to maximize profits. Investment will increase in portable systems that can treat produced water for future use in further hydraulic fracturing. These treatment systems are being created by such companies as Veolia, FlexWater, and M3 Construction. This paper analyzes the various treatment technologies that will be deployed for onsite treatment of produced water, as well as the economic market surrounding these technologies.

IWC INFO-SHARE SUITE: MONDAY NIGHT LIGHTS

Dow Water & Process Solutions is going the distance in performance, reliability and sustainability across technologies including ion exchange, reverse osmosis, ultrafiltration and high-solids filtration. Visit the Dow Huddle Room on Monday, November 7th in Conference Room 12 to watch football and meet with Dow experts. Stop by booth #301 to learn more and enter to win a raffle prize.

• 7:30 – 9:30 PM: kick-off with beer, BBQ and football (The room will be open for the duration of the game.)

MEMBRANES FOR WASTEWATER AND ZLD: ADVANCES IN MEMBRANE TECHNOLOGY FOR CHALLENGING APPLICATIONS

Tuesday, Nov. 8, 8:00–12:00 PM; Room: Salon I

IWC Rep: Jim Summerfield, DOW Chemical Company, Saginaw, MI

Session Chair: Diane Martini, Burns & McDonnell, Kansas City, MO

Discussion Leader: Kristen Bell, Sargent & Lundy, LLC, Chicago, IL

8:00 AM **SESSION INTRODUCTION**

Diane Martini, Burns & McDonnell, Kansas City, MO

Membranes aren't just for demineralizer systems any more. Even though a membrane system won't eliminate your wastewater, it can concentrate your wastewater so that the final ZLD process can be smaller. This session looks at advances in membrane technology for wastewater applications, and includes two FGD wastewater case studies. We will start with an overview of forward osmosis, followed by a case study, then look at an application of the VSEP process and close with an advanced electrodialysis application.

8:10 AM **IWC 16-29: FORWARD OSMOSIS: A PROMISING PROCESS FOR INDUSTRIAL PROCESS WATER RECOVERY**

Georgios Kolliopoulos, Vladimiros Papangelakis, and Alex Karlov, University of Toronto, Toronto, ONT Canada; Amy Holland and Timothy Clark, Forward Water Technologies, Kingston, ONT Canada

Forward osmosis is a recent technology used in desalination and process water recovery that has an energy advantage over several current technologies due to its spontaneity and the switchable nature of the chemicals used. We investigated the effectiveness of aqueous ammonium bicarbonate (NH4HCO3) and carbonated trimethylamine (TMAH:HCO3) as such chemicals and evaluated their separation efficiency from the aqueous process solution. Our results indicate that the separation of TMAH:HCO3 is faster and more efficient.

8:35 AM Discusser: Steve McSherry, Wigen Water Technologies, Chaska, MN

8:45 AM Authors Closure & Floor Discussion

9:00 AM **IWC 16-30: FORWARD OSMOSIS BASED MEMBRANE BRINE CONCENTRATION OF WASTEWATER STREAMS IN COAL-FIRED POWER GENERATION: AN UPDATE**

Marek Nowosielski-Slepowron, MaryTheresa Pendergast, Ph.D., and John Tracy, Oasys Water, Boston, MA

The integration of membrane-based processes into water treatment systems delivers flexible and cost-effective solutions for difficult industrial waters. This paper will discuss the opportunities for incorporation of forward osmosis into power industry wastewater management. In particular, it will highlight the design, start-up, and operation of a zero liquid discharge plant treating flue gas desulfurization wastewater at a coal-fired power facility, which includes at its core the Oasys Water forward osmosis based Membrane Brine Concentrator System.

9:25 AM Discusser: Andrew Carstens, Sargent & Lundy, Chicago, IL

9:35 AM Authors Closure & Floor Discussion

9:50 AM Break

10:20 AM **IWC 16-31: LONG-TERM EVALUATION OF A 50-GPM VIBRATORY SHEAR ENHANCED PROCESS (VSEP) MEMBRANE FILTRATION SYSTEM FOR TREATMENT OF FLUE GAS DESULFURIZATION WASTEWATER**

Jay Renew, Kristen Jenkins, and Keith Hendershot, Southern Research, Cartersville, GA; Chethan Acharya, Ph.D., Southern Company, Birmingham, AL

The vibratory shear enhanced process (VSEP) membrane filtration system developed by New Logic Research, Inc. is a type of dynamic shear-enhanced membrane filtration (DSEMF) system. DSEMF systems operate by creating a high shear rate at the surface of the membrane thereby limiting flux declines and fouling. This high shear rate is achieved through the utilization of rotating disks in the membrane, rotating the membrane, or vibrating the membrane. In the case of the VSEP system, the membrane is vibrated. As a result this dynamic processes, the shear rate is decoupled from the from the inlet flow rate. The permeate flux is enhanced and fouling is limited by reducing particle deposition on the membrane surface. A 50 GPM VSEP system is being evaluated for 5-months at the Water Research Center at Plant Bowen. The system also includes a spiral reverse osmosis (SRO) unit for polishing VSEP permeate.

10:45 AM Discusser: Dennis McBride, Burns and McDonnell, Kansas City, MO

10:55 AM Authors Closure & Floor Discussion

11:10 AM **IWC 16-32: ADVANCES IN EXTREME RECOVERY ION EXCHANGE MEMBRANE SYSTEMS FOR GYPSUM SATURATED REVERSE OSMOSIS BRINES AND AMMONIA REMOVAL**

Mitchell Frank, Malcolm Man, and Ben Sparrow, Saltworks Technologies Inc., Richmond, BC Canada

An advanced electrodialysis platform was developed and tested on multiple industrial water projects. The results solve two industry problems: (1) achieve extreme recoveries on highly scaling waters without chemical softening, (2) remove ammonia from wastewaters without temperature sensitivities in an easily controllable system. Performance, results and economics are presented for projects treating calcium sulfate saturated mining waters as well as the removal and destruction of ammonia from wastewater treatment plant (WWTP) centrate and landfill leachate.

11:35 AM Discusser: Phillip Locke, McKreed & Kim

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion

ZERO LIQUID DISCHARGE – DIFFERENT APPLICATIONS, DIFFERENT CHALLENGES, ONE RESULT

Tuesday, Nov. 8, 8:00–12:00 PM; Room: Salon J

IWC Rep: Patricia Scroggin, Burns & McDonnell, Chicago, IL

Session Chair: Michael Marlett, Aquatech International Corporation, Hartland, WI

Discussion Leader: Brian Powers, HDR Engineering, Inc., Charlotte, NC

8:00 AM **SESSION INTRODUCTION**

Michael Marlett, Aquatech International Corporation, Hartland, WI

Zero Liquid Discharge is presently the focus and one of the preferred technologies for FGD wastewater treatment in coal fired power plants. However, it is also applied to other wastewaters and can be achieved through a hybrid system of utilizing both Thermal and non-Thermal equipment. One of our papers addresses ZLD options for FGD and another addresses a hybrid ZLD system utilized in a coal gasification application. As true ZLD is approached, the challenges to achievement become more pronounced. These commonly include CAPEX, materials selection, and OPEX. Two of the papers in this session address these issues.

8:10 AM **IWC 16-33: OVERCOMING CHALLENGES IN GETTING TO ZERO WITH FLUE GAS DESULFURIZATION (FGD) WASTEWATER**

Krystal Perez, CH2M, Bellevue, WA; Thomas Higgins, CH2M, Reston, VA; Dennis Fink, CH2M, Oakland, CA; Christina Joiner, CH2M, Atlanta, GA

We use a chemistry and mass balance modeling tool to develop a zero liquid discharge method to meet water quality–based standards and ELGs. The method combines FGD system evaporation; fines removal to reduce wastewater flow; wastewater recycling; lime softening to remove magnesium, sulfate, fluoride, and boron; and mixing brine with fly ash to produce disposable solid material. We present a successful example and review factors influencing wastewater quality and quantity.

8:35 AM Discusser: Steve Russell, Black & Veatch, Overland Park, KS

8:45 AM Authors Closure & Floor Discussion

9:00 AM **IWC 16-34: ZERO LIQUID DISCHARGE AT A CHINESE COAL TO CHEMICAL PLANT**

Dave Ciszewski, GE Power, Water & Process Technologies, Bellevue, WA; Yimin Ling, GE Power, Water & Process Technologies, Shanghai, China

DaTang Inner Mongolia DuoLun Coal Chemical Company is a leading Chinese coal-to-olefin producer. The plant couldn't achieve full capacity due to shortfalls in process design, including an undersized waste evaporation pond. To enable DaTang to achieve full capacity and meet discharge regulations, a 175 m3/hr (770 gpm) integrated ZLD wastewater treatment plant including a membrane bioreactor (MBR), nanofiltration (NF), reverse osmosis (RO) and evaporator was installed to treat high salinity coal gasification process wastewater.

9:25 AM Discusser: William Shaw, Veolia Water Technologies, Plainfield, IL

9:35 AM Authors Closure & Floor Discussion

9:50 AM Break

10:20 AM **IWC 16-35: BY PRODUCTS RECOVERY FROM ION EXCHANGE SALINE BRINE USING ELECTRODIALYSIS**

Elisabeth Vaudevire, PWN Technologies, Andijk, Netherlands

Anion exchange resin regeneration of a newly built ion exchange system for treatment of surface water leads to the production of 24 m3/h of saline NOM rich brine. The extraction of salts and humic substances (as part of the NOMs) from the AIX brine by electrodialysis was investigated as a financially/ environmentally attractive alternative to discharge. High quality humic substances can be recovered as a substantial resource with an added value for use in agriculture.

10:45 AM Discusser: John Van Gehuchten, HDR Engineering, Inc., Ann Arbor, MI

10:55 AM Authors Closure & Floor Discussion

11:10 AM **WC 16-36: ZLD SYSTEM CORROSION CAUSES AND MITIGATION - A CASE STUDY**

Daniel Sampson, WorleyParsons, Vallejo, CA

A power plant experienced severe corrosion of the ZLD system's crystallizer recirculation piping and other components including several through-wall failures. This paper discusses several questions raised during the investigation including possible causes, an evaluation of Super Duplex A2507 as an acceptable alloy for the recirculation pump application, an evaluation of the ZLD feedwater to examine design vs. actual chemistry, and recommended design and performance modifications to minimize the potential for future corrosion.

11:35 AM Discusser: Caroline Sui, GE Power, Water & Process Technologies, Trevose, PA

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion

INDUSTRIAL STEAM GENERATION: WHAT QUALITY DO WE WANT AND WHY DO WE CARE?

Tuesday, Nov. 8, 8:00 –2:00 PM; Room: Salon M

IWC Rep: Colleen Layman, HDR Engineering, Inc., Janesville, WI

Session Chair: Vickie Olsen, Honeywell, Altamonte Springs, FL

Discussion Leader: Jim Dromgoole, Fort Bend Services, Stafford, TX

8:00 AM **SESSION INTRODUCTION**

Vickie Olsen, Honeywell, Altamonte Springs, FL

Good steam and boiler water quality are essential to reduce corrosion and scaling both for process and utility operations. This session will covers case studies at sugar mills and utilities at different steam pressure levels where locations experienced problems when the quality was not good enough, and how these issues were resolved.

8:10 AM **IWC 16-37: MONITORING INDUSTRIAL STEAM PROPERTIES AT A TANZANIAN SUGAR MILL**

David Daniels, M&M Engineering Associates, Leander, TX

A sugar mill in Tanzania installed a new bagasse-fueled boiler that operated at 45 bar to supply super-heated steam to a small single shaft turbine/generator set Adding a steam turbine for power generation required that the sugar mill monitor steam purity for the first time. Additional instrumentation and training were required for mill chemistry personnel. This paper will discuss the approach that was taken to adapt steam chemistry monitoring at this site.

8:35 AM Discusser: David B. Clayton, PPM Services Inc., South Houston, TX

8:45 AM Floor Discussion & Closure

9:00 AM IWC 16-38: MONITORING INDUSTRIAL STEAM PURITY: WHY WAIT?

Eric Kangas and Tony Banweg, NALCO Water, an Ecolab Company, Naperville, IL

Industrial steam generating systems provide steam for a wide range of uses. Inadequate steam purity can create conditions that result in efficiency losses, equipment failures, decreased product quality and potential safety concerns. Continuous or periodic monitoring of steam purity provides visibility to potential issues before they become significant operational concerns. This paper will discuss steam purity requirements, methods for accurate monitoring and important considerations in industrial applications.

9:25 AM Discusser: James Faust, Texas Municipal Power Agency, Anderson, TX

9:35 AM Authors Closure & Floor Discussion

9:50 AM Break

10:20 AM IWC 16-39: REPEAT CYCLE CHEMISTRY SITUATIONS: PRECURSORS TO FUTURE DAMAGE IN INDUSTRIAL UTILITY PLANTS

Kevin Shields, Athlon Solutions, Manchester, MD

Chemistry-related damage events in fossil utility steam generators and steam turbines can be linked to operation with certain repeat cycle chemistry situations. When multiple repeat cycle chemistry situations are present the risk of future damage is significant. Repeat cycle chemistry situations should be regarded as root causes of damage mechanisms. Application of the repeat cycle chemistry situations philosophy to an industrial cogeneration facility is presented as a case study.

10:45 AM Discusser: Gene Cotton, MECO; George Bodman Inc., Vidor, TX

10:55 AM Authors Closure & Floor Discussion

11:10 AM IWC 16-40: INDUSTRIAL POWER PLANT TURBINE GENERATOR RETROFIT PROJECT

David Cline, Sheppard T Powell Associates, LLC, Baltimore, MD; Bryan Martin, Westervelt Lumber, Moundville, AL

This presentation discusses the selection, installation and initial operation of a turbine generator at a lumber mill designed to take advantage of excess steam capacity from boilers fired with a renewable energy source (primarily sawdust). A discussion of turbine damage after about one year of operation and subsequent mechanical, water treatment, and chemistry surveillance changes which were implemented is included.

11:35 AM Discusser: Philip Hazen, Waterworks Services, Pasadena, TX

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion

FGD WASTEWATER TREATMENT EXPERIENCE

Tuesday, Nov. 8, 8:00–12:00 PM; Room: Salon K/L

IWC Rep: Brad Wolf, Berkeley Research Group, LLC, Pittsburgh, PA

Session Chair: Mike Preston, Black & Veatch, Overland Park, KS

Discussion Leader: Jonathan Shimko, Tetra Tech, Pittsburgh, PA

8:00 AM **SESSION INTRODUCTION**

Mike Preston, Black & Veatch, Overland Park, KS

FGD wastewater treatment focus has taken a more practical focus since the updated ELG rule was issued in 2015. Utilities and their engineers are focused on evaluating FGD wastewater treatment alternatives and implementing cost effective solutions to achieve compliance. This Session will offer papers focused on several proven technologies and one paper offering practical FGD wastewater implementation suggestions. It will be a good review of the current state of FGD wastewater treatment practices.

8:10 AM **IWC 16-41: CASE STUDIES OF POWER PLANTS IMPLEMENTING THREE DIFFERENT FGD COMPLIANCE SOLUTIONS**

Nelson Fonseca and Joe Tinto, GE Water & Process Technologies, Bellevue, WA; Travis Reynolds, GE Power, Knoxville, TN

FGD waste water is one of the streams affected by the ELG rule, and represents a particular challenge due to the stringent limits placed on nitrite/nitrates, mercury, selenium, and arsenic. Meeting these limits consistently can be challenging given the upstream process variability caused by load cycling, fuel changes, etc. This paper examines three case studies highlighting different approaches to treating FGD waste water, i.e. brine concentration plus crystallization, chemical precipitation plus bio-treatment, and spray dyer evaporation.

8:35 AM Discusser: Jason Monnell, Tetra Tech, Pittsburgh, PA

8:45 AM Authors Closure & Floor Discussion

9:00 AM **IWC 16-42: SALT DRYER TECHNOLOGY FOR ZERO LIQUID DISCHARGE**

Michael Klidas, Babcock & Wilcox Company, Barberton, OH

This paper will explore the use of spray dryer evaporation technology to evaporate the wastewater which results in a true ZLD discharge – a dried salt cake. Pilot testing results of the technology will be reviewed, along with estimates of the economic impact of such an installation on a typical large coal-fired power plant to evaporate WFGD wastewater. Various waste blow-down flow rates will be evaluated.

9:25 AM Discusser: Steven Feeney, Steve Feeney Consulting, LLC, Lancaster, OH

9:35 AM Authors Closure & Floor Discussion

9:50 AM Break

10:20 AM **IWC 16-43: CASE STUDY - ALTERNATIVES FOR COMPLIANCE WITH ELG RULE AT MIDWEST UTILITY**

Bryan D. Hansen, P.E., Burns & McDonnell, Centennial, CO

This paper will present the various FGD wastewater treatment alternatives considered for compliance with the ELG rule at a large Midwest utility. FGD wastewater treatment alternatives evaluated included physical / chemical / biological treatment, air preheater bypass evaporator, iron adsorption, gas fired spray dryer, thermal evaporation,

evaporation ponds, and SBS injection. The paper will discuss the advantages and disadvantages of each alternative. Capital and operating cost data will be provided along with implementation schedules.

10:45 AM Discusser: Paul Togna, Envirogen Technologies, Inc., East Windsor, NJ

10:55 AM Authors Closure & Floor Discussion

11:10 AM IWC 16-44: WET FLUE GAS DESULFURIZATION (WFGD) WASTEWATER TREATMENT SYSTEMS—MECHANICAL DESIGN TIPS

Thomas Higgins, Ph.D., P.E., CH2M, Reston, VA; Dennis Fink, CH2M, Oakland, CA; Brian Choi, CH2M, Atlanta, GA

We identify mechanical aspects key to ensuring that effluent complies with recent ELGs. We present equipment choices (mixers, etc.) that promote precipitation/adsorption of metals and growth of sturdy particles while minimizing shear. Our closed-loop sludge wasting and recycle design maintains scour velocity in piping, minimizing plugging of FGD solids and the need for flush water. We discuss designs to minimize variability in biological treatment parameters, promote ease of O&M, and provide adaptability for future changes.

11:35 AM Discusser: Mitch Mueller, Black & Veatch, Overland Park, KS

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion

ADVANCEMENTS IN MINE WATER TREATMENT STRATEGIES

Tuesday, Nov. 8, 1:15–5:00 PM; Room: Salon I

IWC Rep: Paul Pigeon, Golder Associates Inc., Lakewood, CO

Session Chair: Michael Bluemle, Solenis LLC, Wilmington, DE

Discussion Leader: Jeff Easton, WesTech Engineering, Inc., Salt Lake City, UT

1:15 PM **SESSION INTRODUCTION**

Michael Bluemle, Solenis LLC, Wilmington, DE

Continuously evolving environmental regulations and limited or compromised water resources have spurred the development of new technologies and reuse strategies in the mining industry. In this session, case studies demonstrating the efficacy of two distinct approaches to heavy metal removal are highlighted. A third paper describes the challenges associated with nutrient removal in cold climates. Lastly, this session concludes with discussion of government-driven efforts to treat and reuse mine effluent for hydraulic fracturing operations.

1:25 PM **IWC 16-45: ELECTROCOAGULATION TREATMENT OF HEAVY METALS FROM MINE IMPACTED WATER**

Denney Eames, P.E. and Jacob Aylesworth, Watertectonics, Everett, WA

A presentation of pilot data for three (3) mine impacted wastewaters. The primary contaminates were lead, zinc, cadmium and copper with some waters also containing arsenic, antimony, and thallium. Three very different water sources were studied, including;

- Underground mine dewatering
- Tailings stormwater runoff
- Smelter environmental cleanup water

Contaminate removal data will be presented along with bio-toxicity testing results. CAPEX and OPEX estimates for the full scale system will also be compared to other onsite chemical treatment operations.

1:50 PM Discusser: Neil Kern, P.E., Duke Energy, Charlotte, NC

2:00 PM Authors Closure & Floor Discussion

2:15 PM **IWC 16-46: EVALUATING EFFECTIVENESS AND PERMANENCE OF SELENIUM TREATMENT IN SOLID AND LIQUID MATRICES VIA AQUEOUS-MEDIATED ZERO VALENT IRON REACTION**

Scott Grieco, Danielle Singer, and Gary Bement, OBG, Syracuse, NY

Treatment of selenium in water and immobilizing it in leachable solid matrices is of increasing concern. Chemical reduction and stabilization using zero valent iron (ZVI) is applicable to both matrices. This paper presents the chemistry of ZVI treatment along with data from wastewater and solid matrix treatment applications. Matrix challenges and critical variables that effected treatment are identified. The data support successful treatment using ZVI which converts ionic selenium to an insoluble zero valent state.

2:40 PM Discusser: Joe Tamburini, Tetra Tech, Denver, CO

2:50 PM Authors Closure & Floor Discussion

3:05 PM Break

3:20 PM **IWC 16-47: COLD CLIMATE NITRIFICATION AND DENITRIFICATION OF GYPSUM SATURATED MINING EFFLUENT**

Nabin Chowdhury and Adriano Vieira, Degremont's North American Research and Development Center, Ashland, VA; Amit Kaldate and Brian McGovern, SUEZ Treatment Solutions, Richmond, VA

Mining process often generate effluent containing high ammonia-N, gypsum, toxic metals (e.g. nickel, cobalt, lead, zinc etc.), and residual organic reagents. Several bench-scale moving bed biofilm reactor (MBBR) systems were tested to assess its capability as a full-scale treatment systems for biological nitrogen removal. Test results revealed that the MBBR system was an efficient and sustainable solution to meet the regulatory effluent ammonia-N discharge limits for mining industries even in the cold climate.

3:45 PM Discusser: Floyd Griffiths, WesTech Engineering, Salt Lake City, UT

3:55 PM Authors Closure & Floor Discussion

4:10 PM **IWC 16-48: ANION EXTRACTION FROM MINE WATER USING HYDROFLEX TECHNOLOGY**

Todd Beers and Mike Schrock, Winner Water Services, Sharon, PA; David Dreisinger, Ph.D., Jianming Lu, and Buming Chen, University of British Columbia, Vancouver, British Columbia; Gary Kordosky, Consultant in Solvent Extraction, Phoenix, AZ

The Winner Water HydroFlex system is an adaptable water treatment technology to extract anions such as nitrate, selenate and sulfate from waste water streams. HydroFlex includes solvent extraction loading, scrubbing and stripping with a strong base anion exchange solvent. HydroFlex has been tested at the demonstration plant scale in Sarver, Pennsylvania for sulfate removal from mine-affected water. Recently, the technology has been tested for removal of nitrate from mine-affected water with selectivity over sulfate and selenate. Conveniently, nitrate may be stripped as a strong solution of calcium nitrate using a milk of lime strip solution. Calcium nitrate may be marketable as a fertilizer product, avoiding the cost of nitrate disposal. Testing of HydroFlex will be presented and discussed along with economic analysis.

4:35 PM Discusser: Samuel Billin, Linkan Engineering, Elko, NV

4:45 PM Authors Closure & Floor Discussion

5:00 PM Conclusion

NEW TRENDS AND TECHNOLOGIES IN INDUSTRIAL WASTEWATER REUSE

Tuesday, Nov. 8, 1:15–5:00 PM; Room: Salon J

IWC Rep: Bill Willersdorf, Veolia Water Technologies, Randolph, NJ

Session Chair: John Van Gehutchen, HDR, Pittsburgh, PA

Discussion Leader: John Yen, Graver Water Systems, Inc., New Providence, NJ

1:15 PM **SESSION INTRODUCTION**

John Van Gehutchen, HDR, Pittsburgh, PA

Demand for water reuse continues to increase across industries. This session includes a number of innovative ways of accomplishing reuse, including the treatment of wastewaters with high temperatures and high dissolved solids. Full scale projects and a pilot evaluation; as well as improvements in technology to drive cost down for the Owner, will be presented.

1:25 PM **IWC 16-49: INDUSTRIAL WASTE WATER RECYCLING AND ENERGY CONSERVATION USING HIGH TEMPERATURE, RO MEMBRANES**

Rich Franks, Joshua de la Cruz, and Craig Bartels, Hydranautics, Oceanside, CA; Gerry Van Gils, Kemco, Clearwater, FL

This paper will review the development and use of high temperature RO membranes in various applications. It will discuss the limitations of conventional RO membrane and RO element's materials of construction. The paper will go on to present the design and operational challenges of a full scale industrial waste recycling system treating laundry waste water at temperatures of 50 C using ceramic MF and high temperature RO.

1:50 PM Discusser: Jane Kucera, Nalco Water/An Ecolab Company, Naperville, IL

2:00 PM Authors Closure & Floor Discussion

2:15 PM **IWC 16-50: TREATMENT WITH MICROFIBER CLOTH, ULTRAFILTRATION, AND DOUBLE-PASS REVERSE OSMOSIS ALLOWS REUSE OF HIGH-SALINITY INDUSTRIAL WASTEWATER**

Dave Holland, Aqua-Aerobic Systems, Inc., Loves Park, IL; Anthony Rogers, The Lubrizol Corporation, Deer Park, TX

This presentation details a pilot study treating high-salinity wastewater from the production of specialty chemical additives. The study used pretreatment with microfiber filtration and low-pressure ultrafiltration, followed by two-pass reverse osmosis. The maximum suspended and dissolved solids were reduced from 200 to 2 mg/l and 17,000 to 22 mg/l, respectively, with relatively low feed pressure and no observed membrane fouling (pressure drop increase). In addition, recoveries approached 50%, typical of seawater and other high-salinity applications.

2:40 PM Discusser: Loraine Huchler, MarTech Systems, Inc., Lawrenceville, NJ

2:50 PM Authors Closure & Floor Discussion

3:05 PM Break

3:20 PM **IWC 16-51: FIRST-OF-A-KIND MODULAR BRINE CRYSTALLIZATION SYSTEM**

Charlotte Bessiere and William Shaw, Veolia Water Technologies, Plainfield, IL

A newly developed modular thermal wastewater treatment system enables to treat high TDS wastewaters such as FGD scrubber blowdown or produced water from oil and gas extraction. The modular unit allows for water recovery for reuse, and the resulting mixed salts can be disposed either as a solid or as a concentrated brine slurry. The design is a high-efficiency, MVR-driven forced circulation brine crystallization system, inherently scaling and fouling-resistant. The modular crystallizer has numerous advantages over a non-modular system in terms of transportation costs, overall project schedule, installation sequence, installed footprint, and installed cost.

3:45 PM Discusser: HG Sanjay, Bechtel Corporation, Reston, VA

3:55 PM Authors Closure & Floor Discussion

4:10 PM **IWC 16-52: IMPROVEMENTS IN ELECTRODIALYSIS PERFORMANCE, MODULE CONSTRUCTION AND SYSTEM DESIGN FLEXIBILITY**

Jonathan Wood, Michael Shaw, and Patrick Buzzell, Evoqua Water Technologies, Lowell, MA

A new cross-flow EDR module design and new high-performance membranes have been developed, which increase membrane utilization and packing density while enabling automated assembly techniques. This leads to lower capital cost and energy consumption. This paper will describe results of a field installation using the new EDR device to treat the reject from a reverse osmosis system. Salt removal, system recovery and operational costs will be discussed.

4:35 PM Discusser: Harry Cummings, Graver Water, New Providence, NJ

4:45 PM Authors Closure & Floor Discussion

ASME SPONSORED SESSION: FUNDAMENTALS OF WATER TREATMENT IN INDUSTRIAL STEAM GENERATION SYSTEMS

Tuesday, Nov. 8, 1:15–5:00 PM; Room: Salon M

IWC Rep: Debbie Bloom, Nalco Champion, An Ecolab Company, Naperville, IL

Session Chair: Kevin Shields, Athlon Solutions, Geismer, LA

Discussion Leader: Tony Banweg, Nalco Champion, An Ecolab Company, Naperville, IL

1:15 PM **SESSION INTRODUCTION**

Kevin Shields, Athlon Solutions, Geismer, LA

Technical papers will be presented by four widely recognized industry experts. Each paper will focus on a topic related to the basics of industrial water treatment and its applicability to working plants. Subjects covered include condensate treatment, feed water treatment and deaeration, boiler water treatment, and steam. Following the presentations the speakers will convene as a panel to address questions from session attendees.

1:25 PM **IWC 16-53: CORROSION CONTROL FOR THE INDUSTRIAL PLANT STEAM-CONDENSATE SYSTEM**

Debbie Bloom, Nalco Champion, Naperville, IL

Corrosion of industrial plant steam condensate systems has caused steam heated equipment failures resulting in lost production plus increased equipment repair and replacement costs. This paper will provide a basic understanding of the causes of condensate system corrosion, the effects of steam and condensate system design on corrosion potential, the chemistries that are employed to control corrosion and the monitoring recommended to ensure effective protection of important equipment throughout the plant.

1:50 PM **IWC 16-54: FEEDWATER AND DEAERATION WITHIN INDUSTRIAL STEAM GENERATION SYSTEMS**

Edward Beardwood, Solenis LLC, Wilmington, DE

Control of dissolved oxygen in the boiler feedwater is of paramount importance to effectively prevent corrosion of carbon steel and copper alloy materials in industrial steam water cycles. The principals of thermomechanical and chemical deaeration of steam generator feedwaters in low, medium and high pressure system will be covered. Plant best practices for operational control to avoid feedwater and overall steam generation system corrosion are also discussed. Trouble shooting techniques available to achieve operational best practices and control are provided.

2:15 PM **IWC 16-55: AN OVERVIEW OF SCALE AND CORROSION MECHANISMS AND CONTROL PROGRAMS IN INDUSTRIAL BOILER SYSTEMS**

John Kelly, Water Treatment R&D Consulting, Inc, West Chicago, IL

Scale deposition on heat transfer surfaces can seriously affect steam generation in industrial steam boilers and generators. Deposition can lead to loss in efficiency, serious corrosion, short and long term overheating problems leading ultimately to tube failures. Corrosion problems associated with deposits are generally ductile gouging or caustic gouging (under-deposit corrosion). Internal treatment effectiveness will be discussed.

2:40 PM **IWC 16-56: CHEMISTRY ASPECTS OF INDUSTRIAL TURBINES**

James Bellows, James Bellows and Associates, Maitland, FL

Industrial turbines appear in a wide variety of applications, often under conditions different from those for utility turbines. They may be variable speed. They may be used for pressure reduction device, as backpressure turbines. The steam may not always be needed so the turbine may be idle over a moist condenser that is shared with other turbines with corrosion. They may be non-reheat turbines and washable on-line. The steam purity recommendations may be different.

3:05 PM **FLOOR DISCUSSION**

VOLUME AND COST REDUCTION CONSIDERATIONS FOR FGD WASTEWATER TREATMENT

Tuesday, Nov. 8, 1:15–5:00 PM; Room: Salon K/L

IWC Rep: John Lucey, McKim and Creed, Raleigh, NC

Session Chair: William Kennedy, Duke Energy, Charlotte, NC

Discussion Leader: Dave Riedel, P.E., Arcadis, Wexford, PA

1:15 PM **SESSION INTRODUCTION**

William Kennedy, Duke Energy, Charlotte, NC

This session will discuss a range of topics dealing with the evaluation of FGD wastewater treatment options to include flow and chemistry management of process waters and the reduction or even elimination of discharges. You will have an opportunity to hear about ongoing work in this area from those involved in project execution and research.

1:25 PM **IWC 16-57: AN ELG-READY WATER BALANCE**

Jason Monnell, HC Liang, and Frank Johns, TetraTech, Denver, CO; Farley Wood, Katie Pugh, and Jonathan Shimko, Tetra Tech, Pittsburgh, PA

This paper will present lessons learned from digging deeper to develop a truly accurate and representative water balance. Items that will be covered include:

1. The process of updating the existing facility water balance;
2. Facility system-wide evaluation and assessments;
3. Sampling, flow measurement and validation;
4. Data management; and,
5. Modeling for predictive usages and economic planning.

The end results of sampling, modeling, and analysis can reveal economically impactful results.

1:50 PM Discusser: Brianna Wallace, Geosyntec, Greenville, SC

2:00 PM Authors Closure & Floor Discussion

2:15 PM **IWC 16-58: PASTE APPLICATION FOR THE SUSTAINABLE MANAGEMENT OF COAL-FIRED POWER PLANT'S WASTE**

Sue Longo, P.Eng. and Quintero, P.Eng., Golder Associates, Calgary, AB, Canada; Corne Pretorius, M.Sc., Golder Associates, Vancouver, BC, Canada

Recent regulations have a focus on reducing the environmental impact of the coal fired power plant industry. This has encouraged the power generation companies to investigate different alternatives to manage their waste. Paste technology has in recent years been used in production as well as in extended laboratory test programs to demonstrate the performance of the CCR waste materials as components of paste mixes for final disposal. The case studies and laboratory data have shown positive results demonstrating the capacity of these materials to bind together and produce paste with minimal water release, stacking capabilities and good pipeline transportation properties.

2:40 PM Discusser: Chris Haussmann, Water Systems Specialists, Inc., Seattle, WA

2:50 PM Authors Closure & Floor Discussion

3:05 PM Break

3:20 PM **IWC 16-59: WFGD SULFITE CONTROL AT SEMINOLE ELECTRIC'S PALATKA STATION IMPROVES TRACE ELEMENTS IN THE WASTE WATER STREAM**

Raymond Gansley, General Electric, Knoxville, TN; Troy Patton, Seminole Electric, Palatka, FL; Rikard Hakansson, General Electric, Vaxjo, Sweden

Seminole Electric's Palatka station installed sulfite control on one of ten absorbers during the summer of 2015. Testing during September of 2015 showed the dissolved mercury in the liquid portion of the slurry decreased from greater than 50 μg/l with full oxidation to about 1 μg/l with sulfite control. Testing for selenium treatability and manganese levels was conducted. Mercury re-emissions in the gas phase decreased by approximately 80% with sulfite control.

3:45 PM Discusser: John Van Gehuchten, HDR Engineering Inc., Pittsburgh, PA

3:55 PM Authors Closure & Floor Discussion

4:10 PM **IWC 16-60: EVALUATION OF CHEMICAL INCLUSION PROCESS FOR HEAVY METALS IMMOBILIZATION IN FLUE GAS DESULFURIZATION WASTEWATER THROUGH ETTRINGITE AND MONOPHASE FORMATION**

Phani Peddi, Jay Renew, and Kristen Jenkins, Southern Research, Cartersville, GA; Chethan Acharya, Southern Company, Birmingham, AL

FGD wastewater is characterized with a complex matrix, often complicated with high total and dissolved solids. Chemical inclusion through isomorphic substitution into newly formed pozzolanic products had been proposed as a viable removal mechanism for SeO_4^{2-}. This paper presents the feasibility of application of this chemical inclusion process to remove Se oxyanions by incorporation into freshly formed ettringite or monophase. Bench scale jar tests indicated 80 – 90% removal of SeO_4^{2-} from FGD wastewater.

4:35 PM Discusser: Dale Timmons, NAES Corporation, Issaquah, WA

4:45 PM Authors Closure & Floor Discussion

5:00 PM Conclusion

	SALON I	SALON J	SALON K/L	SALON M
SUNDAY, NOVEMBER 6				
1:00-5:00 PM	CONTINUING EDUCATION WORKSHOPS (ADVANCE REGISTRATION REQUIRED)			
5:00-7:00 PM	WELCOME RECEPTION IN THE EXHIBIT HALL			
MONDAY, NOVEMBER 7				
8:00-11:00 AM	**HISTORICAL REVIEW**	**MAXIMZING WATER REUSE**	**INNOVATIVE ADVANCES**	**PRODUCED WATER**
11:00 AM-12:00 NOON	KEYNOTE SESSION IN SALON K/L/M			
12:00 NOON-1:15 PM	ATTENDEE LUNCHEON IN THE EXHIBIT HALL			
1:15 PM-5:00 PM	**RECENT ADVANCES IN RO**	**COAL FIRED POWER PLANTS**	**COOLING WATER**	**PRODUCED WATER CONDITIONING**
5:00-7:00 PM	ATTENDEE RECEPTION IN THE EXHIBIT HALL			
TUESDAY, NOVEMBER 8				
8:00 AM-12:00 NOON	**MEMBRANES FOR WASTEWATER**	**ZLD APPLICATIONS**	**INDUSTRIAL STEAM GENERATION**	**FGD WASTEWATER**

	SALON I	SALON J	SALON K/L	SALON M
12:00 NOON-1:15 PM	ATTENDEE LUNCHEON IN THE EXHIBIT HALL			
1:15 PM-5:00 PM	**MINE WATER TREATMENT**	**INDUSTRIAL WASTEWATER**	**FGD WASTEWATER TREATMENT**	**ASME SESSION: INDUSTRIAL STEAM GENERATION**
5:00-7:00 PM	ATTENDEE RECEPTION IN THE EXHIBIT HALL			
WEDNESDAY, NOVEMBER 9				
8:00 AM-12:00 NOON	**ION EXCHANGE**	**INDUSTRIAL WASTEWATER**	**ADVANCED COOLING SYSTEM CORROSION**	**FGD, CCR, ELG, EPA**
1:00-5:00 PM	CONTINUING EDUCATION WORKSHOPS (ADVANCE REGISTRATION REQUIRED)			
THURSDAY, NOVEMBER 10				
8:00 AM-12:00 NOON	CONTINUING EDUCATION WORKSHOPS (ADVANCE REGISTRATION REQUIRED)			
1:00-5:00 PM	CONTINUING EDUCATION WORKSHOPS (ADVANCE REGISTRATION REQUIRED)			

ION EXCHANGE, NEW WRINKLES IN OLD MAGIC

Wednesday, Nov. 9, 8:00 - 12:00 PM; Room: Salon I

IWC Rep: Bob Applegate, Graver Water Systems, LLC, New Providence, NJ

Session Chair: Peter Meyers, Resintech, Inc., West Berlin, NJ

Discussion Leader: Donna DeFlavis, Dow Water & Process Solutions, Collegeville, PA

8:00 AM **SESSION INTRODUCTION**

Although ion exchange technology is considered mature, there continue to be interesting advances in the state of the art. This ion exchange session focuses on several such wrinkles; the use of granular carbon as pretreatment to remove hydrocarbons from demineralizer feedwater; continuous ion exchange techniques; and new "wrinkles" in ion exchange resin manufacturing. These new techniques help expand the breadth of ion exchange as a potent tool for water treatment engineers.

8:10 AM **IWC 16-61: RARE EARTH METAL IMPREGNATED MEDIA FOR ANION REMOVAL**

William Henderson, John Richardson, Nicholas Seymour, and Vladimir Djukanovic, ChemTreat, Ashland, VA

Phosphate and other contaminants found in industrial effluent are a concern for the environment. One consequence for phosphate discharge is algae blooms which are the result of excess nutrients in lakes and rivers. Local, state and federal regulations in many areas of the United Sates have become more stringent, limiting the amount of phosphate that can be discharged over a given period of time. The most common removal methods for phosphorus include co-precipitation with iron or aluminum salts, resulting in significant sludge formation, reverse osmosis which is energy intensive or anion exchange which lacks anion selectivity leading to premature exhaustion of resins. A new method has been developed for selective removal of phosphorus from wastewater utilizing inorganic rare earth salts and organic polymers. This exciting new technology results in a reduction of sludge produced during precipitation of phosphorus and is more economical than current co-precipitation methods. In addition to phosphorus the removal of other anions has been studied.

8:35 AM Discusser: Shannon Brown, Monsanto, Saint Louis, MO

8:45 AM Authors Closure & Floor Discussion

9:00 AM **IWC 16-62: APPLYING FIRST OF ITS KIND INDUSTRIAL ION EXCHANGE PROCESS BRINGS MUNICIPAL POTABLE WATER TREATMENT FACILITY INTO REGULATORY COMPLIANCE**

Phillip Locke, P.E., McKim & Creed, Inc., Clearwater, FL; Mike Nixon, McKim & Creed, Inc., Sarasota, FL; Ryan Popko, JEA, Jacksonville, FL

Bunnell, Florida was issued a Consent Order for exceeding TTHMs at its treatment plant. Also, finished water hardness levels deteriorated customers' piping and appliances. The city's new 1.0-mgd treatment facility includes a first-of-its-kind, single vessel, "co-removal" ion exchange process that uses both anionic and cationic resins in a single, high-rate, fluidized bed contactor to simultaneously remove natural organic matter and hardness. The city now meets all regulatory requirements and residents enjoy clear, great-tasting water.

9:25 AM Discusser: Robert Loken, Envirogen Technologies, Rockford, IL

9:35 AM Authors Closure & Floor Discussion

9:50 AM Break

10:20 AM **IWC 16-63: DEVELOPMENT OF A CONTINUOUSLY REGENERATED ION EXCHANGE PROCESS USING A SINGLE REACTOR FOR WATER HARDNESS REMOVAL**

Kevin Slough, P.Eng. and Amr Zaky, Ph.D., P.Eng., Filterboxx, High River, AB, Canada

A novel dynamic bed ion exchange process has been investigated for its continuous regeneration potential, small footprint, and low capital and operating cost. A pilot scale study using a strong acid cation resin was conducted to evaluate the system's process stability during continuous regeneration at constant influent flow-rates and variable regenerant loadings to examine the performance envelope of the dynamic bed ion exchange process and effective hardness removal compared to a similar static upflow ion exchange bed.

10:45 AM Discusser: Douglas Kellog, Evoqua Water Technologies, Rockford, IL

10:55 AM Authors Closure & Floor Discussion

11:10 AM **IWC 16-64: REDUCING DEMINERALIZER COST WITH SHALLOW SHELL RESINS**

Francis Boodoo, Fabio Sousa, Carmen Iesan, and Sean Kennedy, Purolite, Bala Cynwyd, PA

Recent introduction of shallow shell anion resins for demineralization have resulted in cost savings ranging between 15 to 40%. Use of Type I and Type II versions in counter-flow and co-flow regenerated systems show silica leakages that are generally 20 to 65% lower than standard resins, respectively. This is borne out by both laboratory and commercial installations that are discussed in this paper.

11:35 AM Discusser: Matthew Roth, The Dow Chemical Company, Collegeville, PA

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion

RESERVE PAPER: IWC 16: GROUNDWATER TREATMENT FOR THE REMOVAL OF ARSENIC AND URANIUM

Michael Slaby and Amir Baum, Pure Effect Inc., Fullerton, CA; Peter Meyers and Frank DeSilva, ResinTech Inc., West Berlin, NJ

This paper discusses how the system was conceived, built, certified to state standards, and installed. Results are discussed along with how the system was validated and accepted by the state. The spent media will be disposed as TENORM waste at a State approved disposal site.

INDUSTRIAL WASTEWATER TREATMENT

Wednesday, Nov. 9, 8:00 - 12:00 PM; Room: Salon J

IWC Rep: John Lucey, McKim and Creed, Raleigh, NC

Session Chair: Joseph Guida, Fluor, Sugar Land, TX

Discussion Leader: Brad Spindler, Wunderlich-Malec Engineering, Green Bay, WI

8:00 AM **SESSION INTRODUCTION**

Joseph Guida, Fluor, Sugar Land, TX

The 2016 Industrial Wastewater Treatment Session encompasses a wide range of wastewater treatment challenges from refinery and pharmaceutical wastes to meat packing wastes. In this session, papers are featured that discuss the practical application of new technology such as immobilized cell bioreactors and membrane biological reactors. In addition, attendees will gain valuable insight from experience relating to startup and turnaround of conventional treatment systems.

8:10 AM **IWC 16-65: WASTEWATER TREATMENT PLANT STARTUP ISSUES AT A NEW BEEF PACKING PLANT**

Chris Malinowski, HDR, Houston, TX

A new beef packing plant recently opened in Tama, Iowa and is designed to process up to 2,200 head per day. The facility required a new wastewater treatment plant in order to comply with more stringent wastewater discharge limitations. The team faced a number of challenges during commissioning of the new facility including unexpected variations in organic and hydraulic loading, extremely cold temperatures, and procuring qualified plant operations personnel. These issues and the lessons learned will be the focus of this presentation.

8:35 AM Discusser: Kenny Chen, Fluor Enterprises, Inc., Aliso Viejo, CA

8:45 AM Authors Closure & Floor Discussion

9:00 AM **IWC 16-66: ACTIVE PHARMACEUTICAL INGREDIENTS (API) REMOVAL FROM INDUSTRIAL WASTEWATER USING A MBR/ OZONE ADVANCED TREATMENT**

Abigail Antolovich, P.E., Xylem, Denver, CO; Greg Claffey, Xylem, Charlotte, NC; Achim Ried and Christoph Kullmann, Xylem, Herford, Germany

This paper discusses performance of an advanced treatment solution using a membrane bioreactor (MBR)/ozone process to remove Active Pharmaceutical Ingredients (API's). The facility is among the first full-scale pharmaceutical manufacturing sites to build and operate a wastewater treatment system specifically designed to remove API's from wastewater, producing water that is suitable for reuse as make up for cooling towers.

9:25 AM Discusser: Jofre Santos, Jr., Wunderlich-Malec Engineering, Green Bay, WI

9:35 AM Authors Closure & Floor Discussion

9:50 AM Break

10:20 AM **IWC 16-67: TEMPORARY PHENOL OXIDATION PROGRAM TO SUPPORT A REFINERY AERATION BASIN TURN AROUND - LAB TREATABILITY TESTING THROUGH SUCCESSFUL FULL SCALE IMPLEMENTATION – A CASE STUDY**

Michael Fagan and George Deshinsky, USP Technologies, Atlanta, GA; Timothy Ruth and Craig Anderson, United Refining Company, Warren, PA

United Refining Company operates a 70,000 barrel/day petroleum refinery in Warren, Pennsylvania. In 2015, a maintenance turnaround of the wastewater aeration tank was undertaken. During the planned 70 day turn around, the refinery needed a temporary chemical oxidation program to maintain compliance with permitted effluent phenol levels. This paper will present data and key learnings from all phases of this successful project, including laboratory treatability testing, process design; full scale implementation; and successful completion.

10:45 AM Discusser: Americus Mitchell, Fluor, Spring, TX

10:55 AM Authors Closure & Floor Discussion

11:10 AM **IWC 16-68: SELENIUM REMOVAL FROM REFINERY WASTEWATER USING IMMOBILIZED CELL BIOREACTOR TECHNOLOGY**

Rachel Hanson, Honeywell UOP, Englewood, CO; Bill Sheridan and Steve Lupton, Honeywell UOP, Des Plaines, IL

Selenium removal continues to pose challenges in industrial wastewater treatment. UOP XCeed™ bioreactor technology is an advanced, biological treatmentsystem that has been commercially proven to reduce selenium levels. Selenium removal from wastewater at a refinery was tested at bench scale and with an onsite pilot demonstration. Selenium was efficiently reduced to the $<50\ \mu g/L$ limit required for discharge to the local city sewer. A full-scale treatment system has been designed and is being implemented.

11:35 AM Discusser: Ramesh Kalluri, Kalluri Group, Inc., Houston, TX

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion

RESERVE PAPER: ANAEROBIC TREATMENT FOR INDUSTRIAL WASTEWATER - CRITICAL FACTORS FOR A SUCCESSFUL START-UP AND OPERATION

Francis J. DeOrio, O'Brien & Gere, Syracuse, NY; Sara Martin, P.E., Critical Path Engineering Solutions, PLLC, Cazenovia, NY

Anaerobic digestion presents a sustainable solution for converting organic waste material into renewable energy and other beneficial reuse products. It is an especially import treatment consideration for high-strength organic wastes typically found in the food and beverage industry. However, the anaerobic digestion process has a narrow window of conditions, namely pH and temperature, at which the microorganisms can exist and thrive. Anaerobic microorganisms are also sensitive to chemicals that may be present in the wastewater from production or sanitation practices. Careful evaluation of the wastewater matrix and identification of possible interfering or inhibitory properties is important for long term successful operation. This paper presents the challenges and lessons learned from the start-up and operation of anaerobic treatment plants at manufacturing facilities.

ADVANCED COOLING SYSTEM CORROSION AND SCALE CONTROL TECHNOLOGIES

Wednesday, Nov. 9, 8:00 - 12:00 PM; Room: Salon M

IWC Rep: Ken Dunn, Solenis, Shrewsbury, MA

Session Chair: Ray Post, ChemTreat, Glen Allen, VA

Discussion Leader: Sidney Dunn, Baker Hughes, Sugar Land, TX

8:00 AM **SESSION INTRODUCTION**

Ray Post, ChemTreat, Glen Allen, VA

Water reuse goals and environmental regulations are shaping the design and operation of cooling water systems. Alternate water sources with diverse chemistries such as RO permeate and grey water present unique challenges for corrosion and deposit control. Environmental initiatives for improved water utilization efficiency, minimizing liquid effluents, and reduce phosphorus discharge are challenging the status quo for conventional water treatment chemistries. This session features papers on advanced corrosion inhibitors for low hardness waters, kinetic and thermodynamic modeling of scale formation, surface characterization of emerging low phosphorus treatments, and the evaluation of synergistic behavior among deposit control agents.

8:10 AM **IWC 16-69: NEW LOW AND NO HARDNESS COOLING WATER CORROSION INHIBITOR**

David Fulmer, Baker Hughes, Sugar Land, TX; Mary Jane Felipe, Baker Hughes, Sugar Land, TX; Khac Nguyen, Baker Hughes, Sugar Land, TX

Most open recirculating cooling tower treatment programs utilize phosphorous-containing water treatment programs to mitigate corrosion. These phosphate based inhibitors however require some level of calcium to be effective. It is becoming more common for industrial plants to use low or no hardness water as make-up. Therefore, there is a need for a corrosion inhibitor that works in these waters without having to add calcium. This paper details the development of such a corrosion inhibitor.

8:35 AM Discusser: Charles Kuhfeldt, Athlon Solutions, Houston, TX

8:45 AM Authors Closure & Floor Discussion

9:00 AM **IWC 16-70: ELIMINATION OF SIDE STREAM SOFTENING IN A POWER PLANT RECLAIM WATER APPLICATION: NOVEL TERPOLYMER, SIMULATION AND PLANNING CONTROL CALCIUM PHOSPHATE DEPOSITION**

Caroline Sui, Jeff Melzer, and Eric Thungstrom, GE Power, Water & Process Technologies, Trevose, PA

Side stream processing of recirculating cooling water and cooling tower blowdown treatment removes contaminants from cooling water, permitting reuse of the water. Side stream processing can be accomplished via membrane filtration (e.g. reverse osmosis) or softening, both of which are capital intensive operations with high operating expense that require ancillary unit operations (dewatering/solids disposal or brine disposal). This paper discusses an ambitious plan to leverage a novel terpolymer's ability to prevent calcium phosphate deposition in highly stressed water and to eliminate the need for side stream softening. Phosphate concentrations ranging up to 110 ppm were kept soluble in the circulating water despite the introduction of operational upsets of acid loss and water quality variation. The study

clearly demonstrates the potential savings resulting from elimination of an onerous unit operation while permitting water reuse to continue. The ability to monitor the performance and stay ahead of any potential upsets is also discussed.

9:25 AM Discusser: Loraine Huchler, MarTech Systems, Inc., Lawrenceville, NJ

9:35 AM Authors Closure & Floor Discussion

9:50 AM Break

10:20 AM IWC 16-71: SURFACE CHARACTERIZATION OF INTERFACIAL LAYERS TO STUDY THE PERFORMANCE AND EVOLUTION OF PHOSPHATE BASED PROGRAMS IN COOLING WATER APPLICATIONS

Claudia Pierce and Paul Frail, GE Power, Water & Process Technologies, Trevose, PA; Gilad Zorn and Reza Sharghi-Moshtahin, GE Global Research Center, Niskayuna, NY

Advanced surface analytical techniques were used to explore the composition of corrosion inhibition films formed on mild steel surfaces in contact with different phosphate based cooling programs. These corrosion inhibition films have complex multilayered structures that incorporate metal, ceramic and polymeric structures. When the concentration of phosphorus is undetectable in the cooling water system discharge, passivation on the film surface is still maintained and its composition is mostly representative of the water chemistry constituents.

10:45 AM Discusser: Don Akers, Marathon Petroleum, Ashland, KY

10:55 AM Authors Closure & Floor Discussion

11:10 AM IWC 16-72: IN SEARCH OF SYNERGY

Robert Ferguson, French Creek Software, Inc., Phoenixville, PA

Existing models for calculating the minimum effective dosage for scale control have been applied to industrial and oil field scale control treatment optimization since the 1970s, based upon standard correlations. Models typically apply to a single inhibitor. Studies determined the impact of blending inhibitors on the minimum effective dosage. Models were tested based upon synergism, competitive inhibition, and equivalent efficacy. Blend impact upon the maximum controllable driving force is also discussed.

11:35 AM Discusser: Walker Garrison, Valero Energy, San Antonio, TX

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion

FGD, CCR, ELG, EPA – THE ALPHABET SOUP OF COMPLIANCE REALITY

Wednesday, Nov. 9, 8:00 - 12:00 PM; Room: Salon K/L

IWC Rep: Jay Harwood, GE Power, Water & Process Technologies, Oakville, ON, Canada

Session Chair: Lanny Weimer, GE Power, Water & Process Technologies, Ormond Beach, FL

Discussion Leader: Andrew Bohner, Envirogen Technologies, Inc., Ewing, NJ

8:00 AM **SESSION INTRODUCTION**

Lanny Weimer, GE Power, Water & Process Technologies, Ormond Beach, FL

The past couple of years have seen the introduction of new regulations impacting coal-fired power plants. Utilities are faced with a complex web of decisions to make based on limited historical information. Compounding this further is the unique nature of each individual power station. Trying to digest all of this information to ensure sustainability while remaining profitable can be challenging. This session will explore water and mass balance challenges around ELG and CCR rules, evaluation criteria to support decision making for compliance and will offer a look at alternative sources of make-up water to further support sustainability.

8:10 AM **IWC 16-73: UNINTENDED CONSEQUENCES: CCR AND ELG COMPLIANCE IMPACTS ON NON-ELG STREAMS**

Patricia Scroggin, Jason Eichenberger, and Zach Foster, Burns & McDonnell, Kansas City, MO; Bill Skalitzky, Alliant Energy, Madison, WI

This paper will review the unintended consequences that result from modifying operations at coal fired power plants to comply with the Coal Combustion Residuals (CCR) Rule and Steam Electric Power Generating Effluent Limitation Guidelines (ELGs). Many facilities under the CCR Rule have identified impoundment(s) that will require closure, impacting site management of many non-ELG streams currently discharged to CCR impoundments. Data will be presented to demonstrate predicted cost and operational changes associated with these impacts.

8:35 AM Discusser: Derek Henderson, Duke Energy, Raleigh, NC

8:45 AM Authors Closure & Floor Discussion

9:00 AM **IWC 16-74: DEVELOPMENT OF A DECISION SUPPORT MODEL FOR EVALUATING INTEGRATED SOLUTIONS FOR COMPLIANCE TO ELG AND CCR REGULATIONS**

Corne Pretorius and Hannah Chiew, M.SC, Golder Associates, Vancover, BC, Canada; Kirk Ellison, EPRI, Charlotte, NC; Chethan Acharya, Ph.D., P.E., Southern Company Services, Birmingham, AL

The challenge of complying with legislative changes in the power industry leads to a wide range of potential solutions that rely on a combination of different water treatment and waste management technologies. A decision support model was developed in GoldSim to simulate FGD purge water flow and chemistry as a function of coal quality, power plant utilization parameters, process chemistry controls and climate. The model enables a comparison of cost for various potential flow sheets.

9:25 AM Discusser: David Weakley II, GAI Consultants, Homestead, PA

9:35 AM Floor Discussion & Closure

9:50 AM Break

10:20 AM **IWC 16-75: REMOVAL OF UNKNOWN SELENIUM SPECIES FROM FLUE GAS DESULFURIZATION WASTEWATER**

Jay Renew, Kristen Jenkins, and Keith Hendershot, Southern Research, Cartersville, GA; Chethan Acharya, Ph.D., Southern Company, Birmingham, AL

The coal-fired power industry confronts increasing pressure to improve wastewater treatment and disposal practices. The United States Environmental Protection Agency (USEPA) determined that most constituent loadings associated with coal-fired power plants result from wet flue gas desulfurization (FGD) and ash handling systems. In a typical wet FGD system, Ca or Ca-Mg slurry is sprayed into flue gas in order to remove SO2. Along with SO2, trace metals are also removed from the flue gas and accumulate in the FGD system. Purge brines from FGD systems are complex wastewaters that contain significant concentrations of trace metals including As, Cd, Cr, Hg, and Se. The wastewater also contains large amounts of salt in the forms of Ca2+, Mg2+, Na+, SO42-, and Cl-. One of the more difficult heavy metals to remove from FGD wastewater is Se. Se speciation in FGD wastewater can be complex. It has been assumed in the past that Se speciation included only SeO32-/HSeO32- and SeO42-. However, peer-reviewed scientific literature by other researchers has documented the presence of 13 Se species in FGD wastewater utilizing anion-exchange chromatography coupled with inductively coupled plasma-mass spectrometry (AEC-ICP-MS). Two of the Se species documented in previous studies included SeSO32- and SeCN-, but most of the Se are still unknown. The presence of multiple Se species could complicate Se removal from FGD wastewater. Understanding the treatment efficacy of techniques to remove these unknown Se species from FGD wastewater is needed. The primary project objective is to evaluate the removal of unknown Se species through nanofiltration (NF) and ultrafiltration (UF).Bench-scale experiments were conducted to evaluate treatment of real FGD wastewater with NF. Six NFs with midpoint molecular weight cut offs (MWCOs) varying from 150 to 900 Daltons were evaluated in these experiments. Two UF membranes with MWCOs varying from 1,000 to 2,000 Daltons were also evaluated. The feed FGD wastewater, permeate, and concentrate underwent analysis for Se speciation, metals, low level Hg, and anions. The project results indicated that NF membranes with midpoint MWCOs $<$ 400 Daltons removed more than 80% - Se (total and dissolved) and SeVI (dissolved); 70% - MeSeIV (dissolved), SeIV (dissolved), and unknown Se species. All membranes (NF and UF) effectively removed ($>$ 80%) total and dissolved Hg. NF membranes with midpoint MWCOs $<$ 400 Daltons achieved more than 80% softening of FGD wastewater.

10:45 AM Discusser: James Beninati, HDR Engineering, Pittsburgh, PA

10:55 AM Authors Closure & Floor Discussion

11:10 AM **IWC 16-76: CASE STUDY – MEASURING FLOWS TO CLOSE WATER BALANCES FOR ELG COMPLIANCE AND CCR POND CLOSURE**

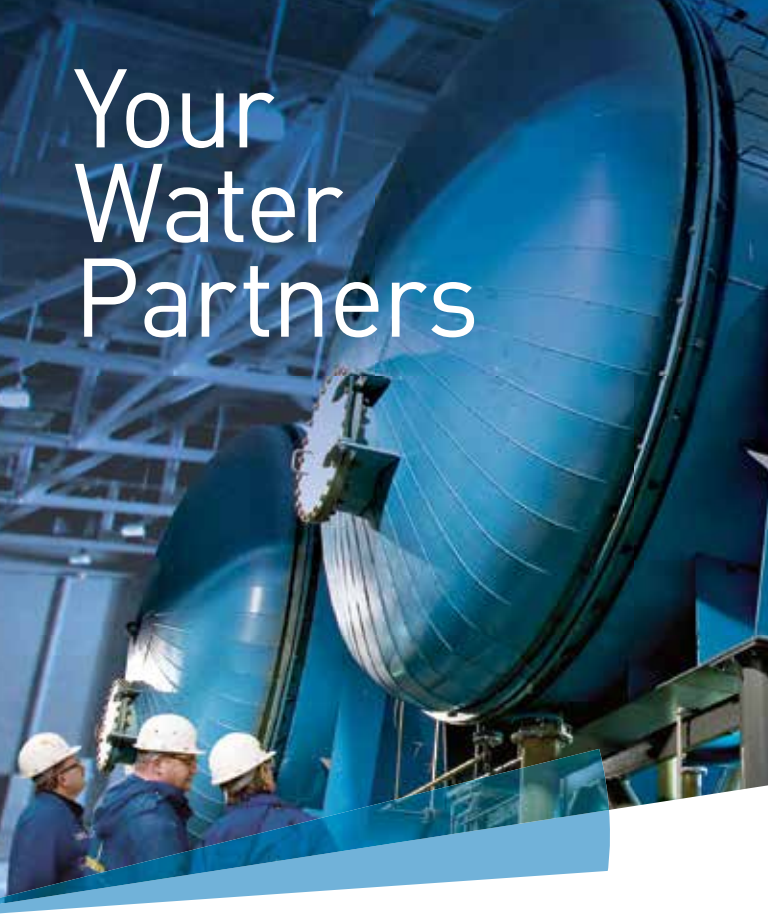
Karen Burchardt, Burns & McDonnell Engineering, Chicago, IL; Keith Ambrose, Duke Energy, Charlotte, NC; Joseph Potts, Duke Energy, Cincinnati, OH; Daniel Elliott and Janel Junkersfeld, P.E., Burns & McDonnell, Kansas City, MO

In response to current regulations, Duke Energy teamed with Burns & McDonnell to measure the flows in several of their plants to close their water balances, quantify the various wastewater streams that must be managed, and plan for closing ponds and rerouting waste streams. This paper will discuss how streams were selected, the various types of flow meters and flow measurement techniques that were used, and lessons learned during the process.

11:35 AM Discusser: Jason Monnell, Tetra Tech, Denver, CO

11:45 AM Authors Closure & Floor Discussion

12:00 Conclusion



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Sunday, Nov. 6; 1:00-5:00 PM

W1: WATER TREATMENT 101

This workshop is a great introductory course covering the basic concepts of water treatment for industry. It will address unit operations (clarification, filtration, lime/soda ash softening, iron and manganese removal, membrane filters, and roughing demineralizers) used in water preparation for industry with emphasis on power, chemical industry, and refineries. It was include treatment of makeup water for cooling water systems as well as boiler water makeup. Wastewater generated by these unit operations and their treatment and disposal will be discussed. Basic water chemistry requirements for low, medium, and high pressure boilers will be considered with chemical conditioning as required.

Dennis McBride, Burns & McDonnell, Kansas City, MO

W2: ION EXCHANGE TECHNOLOGY AND PRACTICAL OPERATING PRACTICES

This workshop provides a detailed review of the various ion exchange processes for softening and demineralizing water as well as preparation for boilers, cooling, and process applications. A section on how to evaluate systems, their resin, operation, and water quality of ion exchange units is an excellent troubleshooting and informative portion of this workshop. A review of the different types of ion exchange resins available along with the newest developments and how those can be applied to provide specific water quality is a must for water treatment system operations. This is a great opportunity to ask questions and solve problems.

Wayne Bernahl, W. Bernahl Enterprises, Ltd., Elmhurst, IL.

W3: REVERSE OSMOSIS - BACK TO THE BASICS, DESIGN AND OPERATION

The application of reverse osmosis (RO) has grown rapidly over the last 15 year. However, some of the basics have been lost in shuffle. Furthermore, many times professionals and operators familiar with ion exchange are now faced with operating RO systems with little or no training. This Workshop covers the basics of RO, from sound design to proper operating techniques. Fouling and concentration polarization, data collection and normalization, cleaning and storage are just some of the topics included in this Workshop. This Workshop is intended for all who need to understand the basics of RO.

Jane Kucera, Nalco Company, an Ecolab Company, Naperville, IL.

W4: WET FLUE GAS DESULFURIZATION (FGD) CHEMISTRY AND OPERATIONAL IMPACTS ON WASTEWATER QUALITY

This workshop will provide an overview of wet FGD chemistry and operating factors that will affect the wastewater quality. The various subsystems of the wet FGD system will be discussed including reagent handling, reagent preparation, absorber internals, recycle slurry, slurry spray headers, mist eliminators, primary dewatering, secondary dewatering, and wastewater treatment. The workshop will discuss the operational chemistry involved in removal of SO2 from the flue gas and highlight how operating parameters like pH, conductivity, ORP, and other issues affect the overall process. The workshop will also address how operation of the wet FGD system can affect the quality of the wastewater being discharged.

Bryan D. Hansen, P.E., Burns & McDonnell, Centennial, CO

Wednesday, Nov. 9; 1:00-5:00 PM

W1A: WATER TREATMENT 101

This workshop is a great introductory course covering the basic concepts of water treatment for industry. It will address unit operations (clarification, filtration, lime/soda ash softening, iron and manganese removal, membrane filters, and roughing demineralizers) used in water preparation for industry with emphasis on power, chemical industry, and refineries. It was include treatment of makeup water for cooling water systems as well as boiler water makeup. Wastewater generated by these unit operations and their treatment and disposal will be discussed. Basic water chemistry requirements for low, medium, and high pressure boilers will be considered with chemical conditioning as required.

Dennis McBride, Burns & McDonnell, Kansas City, MO

W5: VARIOUS USES OF WAC RESIN IN WATER TREATMENT

The general properties of WAC resin will be presented, followed by detailed description of their applications: Used in the H-form: Dealkalization, combined Dealkalization-Softening, NeutraFilter (neutralization of waste effluent of demineralizers) Used in the Na-form: Softening of high TDS water and Produced Water. For each system, design parameters will be discussed and guidelines provided for most efficient regeneration and operation.

Guy Mommaerts, Ion Exchange Services Canada, Inc, Elimira, ON Canada

W3A: REVERSE OSMOSIS - BACK TO THE BASICS, DESIGN AND OPERATION

The application of reverse osmosis (RO) has grown rapidly over the last 15 year. However, some of the basics have been lost in shuffle. Furthermore, many times professionals and operators familiar with ion exchange are now faced with operating RO systems with little or no training. This Workshop covers the basics of RO, from sound design to proper operating techniques. Fouling and concentration polarization, data collection and normalization, cleaning and storage are just some of the topics included in this Workshop. This Workshop is intended for all who need to understand the basics of RO.

Jane Kucera, Nalco Company, an Ecolab Company, Naperville, IL.

W6: THERMAL ZERO LIQUID DISCHARGE PROCESSES

This course is designed to give a basic understanding of the information required for the selection and design of an evaporation system in a wastewater application. It will include the impacts of chemistry, equipment selection and energy source selection as well as provide case studies based on real world applications in a variety of industries.

J. Michael Marlett, P.E., P.Eng., Aqua-Chem ICD, Hartland, WI

Wednesday, Nov. 9; 1:00–5:00 PM

W7: COOLING TOWER WATER SYSTEMS 101- HOW TO DEVELOP A COOLING WATER TREATMENT PROGRAM AND HOW TO DETERMINE IF YOUR PROGRAM IS THE MOST COST EFFECTIVE

This workshop discusses the problems commonly found in Cooling Tower Water systems and the various water treatments that can be used to control or prevent those problems. Specific water treatment chemicals are discussed and their advantages and disadvantages are presented. These specific chemicals are for corrosion, scale, fouling, and microbiological control. They are identified generically and include the most recent developments. The preparation of the complete water treatment program is provided in easy to apply steps. This workshop is excellent for operators, utility mangers, and water treatment suppliers both new on the job and great as a refresher for others. Bring your cooling tower water treatment program information.

Paul Puckorius, Puckorious & Associates, Inc, Arvada, CO

W4A: WET FLUE GAS DESULFURIZATION (FGD) CHEMISTRY AND OPERATIONAL IMPACTS ON WASTEWATER QUALITY

This workshop will provide an overview of wet FGD chemistry and operating factors that will affect the wastewater quality. The various subsystems of the wet FGD system will be discussed including reagent handling, reagent preparation, absorber internals, recycle slurry, slurry spray headers, mist eliminators, primary dewatering, secondary dewatering, and wastewater treatment. The workshop will discuss the operational chemistry involved in removal of SO2 from the flue gas and highlight how operating parameters like pH, conductivity, ORP, and other issues affect the overall process. The workshop will also address how operation of the wet FGD system can affect the quality of the wastewater being discharged.

Bryan D. Hansen, P.E., Burns and McDonnell, Centennial, CO

W8: INDUSTRIAL BOILER WATER (UP TO 1800 PSIG/120 BAR)

The course is intended for those interested in industrial steam systems operating at pressures up to 1800 psig. While some basic theory is covered, the main focus of the course is to provide practical information that can be used to avoid common system problems. The course covers deaerators, boilers, steam turbines and condensate systems from both mechanical operation and chemical treatment aspects. The causes of deposition and corrosion as well as water quality and monitoring guidelines and chemical treatment options are discussed in an informal atmosphere.

Richard Krichten, GE Power, Water & Process Technologies, Trevose, PA

W9: PRODUCED WATER: TREATMENT CHEMICALS STEP-BY-STEP IN SAGD AND CSS PROCESSES

This course is intended for SAGD and CSS chemical technologists, engineers, plant operators and supervisors interested in better understanding the effects of various chemicals on produced water throughout the entire processes in plant facilities. Some basic theory is covered but the primary goal of the course is to provide practical information that can be applied to prevent common system problems. The program material includes inlet separation, de-oiling, evaporators, warm or hot lime softening, filtration and ion exchange. The setting is interactive with past or present plant experiences being shared for the benefit of the course audience.

René Bélanger, P.Eng., Baker Hughes, Calgary, Alberta

Thursday, Nov. 10; 8:00 AM– 12:00 NOON

W10: WATER TREATMENT 201

This course reviews the topics covered in Water Treatment 101 and build on those to provide design and technical details on designing water treatment systems using supplier's equipment information. Unit processes covered in this course are pretreatment softening using lime and soda ash, sodium cycle ion-exchange for softening, demineralization of pretreated raw water using cation/ anion/ mixed-bed ion-exchange systems, reverse osmosis, and EDI. Boiler water chemistry guidelines and chemicals feeds for boiler chemistry control for high pressure power plant boilers, combined cycle plants, and industrial boilers (up to 1500 psi) will be discussed. Advanced wastewater treatment concepts for power plants, industrial plants, and refineries will be included with recycle and reuse when feasible.

Rafique Janjua, Fluor, Sugarland, TX

W11: CONTAMINANTS A TO Z, BEST AVAILABLE REMOVAL TECHNOLOGIES

A whirlwind presentation on the more common contaminants found in water, their general behavior, how they get into water, and the best available technologies for their removal. Chapters include naturally occurring and man-made trace contaminants, radioactive contaminants, plating residuals, oxidation byproducts, organic contaminants, dissolved gasses, and a special bonus section about the bulk ions found in water. The workshop is divided into 8 segments, each with approximately 8 contaminants. Although every contaminant is included in the handout information, not every contaminant will be discussed orally due to time constraints. Students will be asked at the start of the session to suggest which contaminants they are most interested in.

Peter Meyers, ResinTech, Inc., West Berlin, NJ

W12: ELECTRODEIONIZATION (EDI)

Electrodeionization (EDI) is a hybrid of two well-known processes, ion-exchange deionization (IX) and electrodialysis (ED). It was developed to allow the production of deionized water without the use of the hazardous acid and caustic that are required to regenerate ion exchange resins. EDI is now over 25 years old and is used extensively in many industries, especially in the production of deionized water for pharmaceutical formulations, power generation and manufacture of microelectronics/semiconductor devices. It is usually employed as a polishing demineralization step with reverse osmosis (RO) upstream as the roughing demineralizer. This workshop will start by reviewing the principles of the EDI process, how it differs from IX, how EDI modules are constructed, and EDI feed water requirements. It will then focus on practical aspects of EDI system design, operation, maintenance and troubleshooting.

W13: EVAPORATIVE WATER TREATMENT FUNDAMENTALS FOR STEAM GENERATING EOR PROCESSES

Evaporative water treatment may seem complex at surface-level, but once the underlying principles are understood, evaporation system design and operation become very straightforward. This course is designed to explore everything from evaporator design to its integration into various EOR processes: including steam-flood, SAGD and CSS. Students will come away from this course with a practical understanding of how evaporators work, why they work and how they are used in the oil & gas industry to solve real problems. Course matter

will cover evaporative boiler feed water production (either OTSG's or drum boilers) and brine discharge reduction strategies. A particular emphasis will be placed on produced water chemistry variation and design implications. Unit operations such as falling-film evaporation and crystallization will be covered in-depth. Several real-world case studies will be examined to reinforce theoretical principles and students will work through several design optimization problems.

Greg Mandigo, Aquatech International Corp., Hartland, WI

W14: COOLING WATER TREATMENT PROGRAMS AND GUIDELINES WHEN SWITCHING FROM FRESH TO REUSE

This workshop will cover guidelines to be used in developing a cooling water treatment technology going from fresh to recycle waters as makeup. These guidelines will identify possible concerns and potential benefits with recycle water. A step by step approach is provided not only for existing cooling tower water systems but also new systems that can handle almost any recycled waters. A number of case histories are provided. Attendees are encouraged to bring not only any questions but also details on their cooling tower water systems and the recycle water quality being considered. A must workshop for operators, utility managers, and for water treatment suppliers.

Paul Puckorius, Puckorius & Associates, Inc, Arvada, CO

W15: ARSENIC AND SELENIUM IN WASTEWATER TREATMENT

Changes in regulations in the coal-fired power industry and existing standards in the mining industry are but two examples of increased regulatory focus on arsenic and selenium. These ions have not been the focus of emphasis for widespread industrial treatment in the past. Numerous new technologies have been promoted for use in the treatment of arsenic and selenium. However, it is difficult for the environmental personnel responsible for making intelligent decisions in this area to assess the real potential of treatment technologies to cost-effectively achieve the desired goals. This course will provide the background necessary for those concerned with arsenic, selenium or both to make sound decisions about the technical direction of treatment options.

John Schubert, P.E., HDR Engineering, Sarasota, FL

W16: HRSG AND HIGH PRESSURE (>900 PSIG/60 BAR) BOILER WATER TREATMENT AND OPERATION

This workshop will cover the water quality required for high pressure (>900 psig/60 bar) steam boilers including the various treatments being used and new developments relative to protection from scale and corrosion. The course will also cover treatment issues related to pre-boiler systems and the condensate systems and a discussion of controls and troubleshooting techniques. Operators, utility plant supervisors, managers, and engineers can all benefit greatly from the practical information provided in this course.

David Daniels, Mechanical & Materials Engineering, Austin, TX

W17: DEOILING PRODUCED WATER FOR INSITU OILSANDS

Upstream of "Produced Water Treatment" in SAGD or CSS, water that has been separated from the bulk bitumen/dilbit phase, contains varying amounts of hydrocarbon. If not removed from the system this hydrocarbon will negatively impact the performance of Boiler Feed Water pre-treatment equipment such as Lime Softening, Ion Exchange and Evaporators. This introductory course looks at the fundamentals of the

De-oiling system. We will explore the purpose and system design, of specific equipment such as Skim Tanks, Induced floatation (ISF and IGF), as well as Oil Removal Filters (ORF's). We will also discuss industry standards, chemistry, and lessons learned.

Chris Graham, C.G.Consulting, Inc., Calgary, AB Canada

Thursday, Nov. 10; 1–5:00 PM

W18: WASTEWATER TREATMENT 101+

Subjects discussed:

1. Identification of wastewater streams
2. Selective segregation of wastewater streams
3. Pretreatment of segregated streams
4. Terminology & Microbiology of wastewater treatment
5. Primary wastewater treatment unit operations
6. Secondary wastewater treatment unit operations
7. Solids production, its treatment and disposal management

Rafique Janjua, Fluor, Sugarland, TX

W02A: ION EXCHANGE TECHNOLOGY AND PRACTICAL OPERATING PRACTICES

This workshop provides a detailed review of the various ion exchange processes for softening and demineralizing water as well as preparation for boilers, cooling, and process applications. A section on how to evaluate systems, their resin, operation, and water quality of ion exchange units is an excellent troubleshooting and informative portion of this workshop. A review of the different types of ion exchange resins available along with the newest developments and how those can be applied to provide specific water quality is a must for water treatment system operations. This is a great opportunity to ask questions and solve problems.

Wayne Bernahl, W. Bernahl Enterprises, Ltd., Elmhurst, IL.

W19: UF, RO AND EDI MAINTENANCE AND CLEANING

Presentation of common practices in the maintenance of ultrafiltration, reverse osmosis and deionization systems, including best practices for off line clean in place process as well as on site membrane cleaning practices membrane and system life and minimizing operations cost. For ultra-filtration and reverse osmosis the training review will cover preventive maintenance practices, spares replacement frequencies, and non-scheduled maintenance repairs. There will be a detailed discussion of membrane maintenance practices, including why cleaning is important, when CIP or onsite site cleaning should be triggered, the common foulants, preparation of cleaning solutions, standard cleaning procedures, tips and shortcuts, and when off-site membrane cleaning should be considered.Attention will be focused on the key performance indicators for RO/NF membranes and hollow fiber ultrafiltration membranes that should trigger a membrane cleaning process and the variation in procedures and solutions for onsite cleaning for RO/NF membranes for removal of silt, biological materials, naturally occurring organics, calcium carbonate, iron and silica as well as UF membranes for removal of biological materials, silt, naturally occurring organics, and iron. There will also be discussion of membrane autopsies, when they are needed and how to interpret the results. With the increasing use of electrodeionization technology such as continuous deionization the instructor will also touch on best practices in determination when

unit cleaning is required as well as proper chemical cleaning and off site cleaning practices.

Robert Cohen, Evoqua Water Technologies LLC, Rochester, NY

W20: WATER AND WASTEWATER TREATMENT FOR NATURAL GAS DEVELOPMENT

The ongoing development of the unconventional natural gas market was made possible by developments in the fields of directional drilling and hydrofracturing. Hydrofracturing requires large volumes of water, processing of that water to use in hydrofracturing, and handling of the return water from the well after Completion of hydrofracturing. As hydrofracturing water comes in contact with shale, some of the soluble shale constituents dissolve into the hydrofracturing water. Current options for handling of hydrofracturing water include treatment for reuse, treatment for discharge, and deep well disposal. The focus of this course is to provide a foundational understanding of the use of water in hydrofracturing, and the disposition of return water (flowback and produced water) from hydrofractured wells. Areas of emphasis include hydrofracturing water preparation, treatment of flowback water for reuse, evaporation-crystallization of hydrofracturing water, and overall economics of water management. The course serves as a sound introduction to the area for those wishing to learn about shale gas development, and provides detailed information for professionals who may be working with shale gas water.

John Schubert, P.E., HDR Engineering, Sarasota, FL

W21: LEGIONELLA RISK MANAGEMENT

Recent regulations, updated guidelines and the first published U.S. standard have placed the spotlight on managing risks associated with Legionellosis and other waterborne pathogens. A comprehensive understanding of these issues and how to manage the associated risks is now an essential tool for water treatment professionals, building owners and facility managers. This short course will provide the basic tools to understand Legionella, current methodologies for microbial control and especially Legionella, an overview of ASHRAE/ANSI 188-2015, and current guidelines with a focus on cooling water systems.

Jon Cohen, ChemTreat, Inc., Richmond, VA

W22: WATER BALANCE "INS" AND "OUTS" FOR POWER PLANTS

This 4 hour workshop will cover development of a basic water balance, and will discuss 6 sample water balances for different power plant examples, Simple Cycle, Combined Cycle, Coal, IGCC, Combined Cycle ZLD and Coal ZLD. Water balance construction will focus on identifying water quality requirements for end users and their impact on water usage. From water supply to water discharge, water demands will be followed through the plant. Topics will include closed cycle cooling, steam cycle makeup, service water quality, and outage water usage. At the end of the day, students will be able to construct and review water balances, estimate the impact of water and wastewater treatment processes on water usage, understand the different uses of water balances and why many water balances do not actually balance. We will also discuss the impacts of closing ash ponds and methods for estimating the amount of water that will remain for treatment, as well as the hidden water users within the plant that complicate Zero Liquid Discharge applications, and some tips and tricks for flow measurement and identification.

Diane Martini, Burns & McDonnell, Chicago, IL

IWC EXHIBIT HALL

The IWC Exhibit Hall features countless different opportunities to learn about practical and innovative solutions for the industrial water treatment industry from industry leaders. The Exhibit Hall is located inside and outside Salons A–F of the Rivercenter Hotel. The Exhibit Hall hours of operation are:

- Sunday, November 6 from 5:00 - 7:00 PM
- Monday November 7 from 11:30 AM - 1:30 PM and 5:00–7:00 PM
- Tuesday November 8 from 11:30 AM - 1:30 PM and 5:00–7:00 PM

Be sure to join us for lunch on Monday and Tuesday, as well as the evening receptions Sunday, Monday, and Tuesday. Luncheons and receptions are open to all registered attendees. A listing by booth number of all 2016 IWC Exhibitors is provided below. On the following pages, you will find a detailed description of these Exhibitors, including contact information and company description.

3M - MEMBRANES BUSINESS UNIT

Booth: 322
Contact: Donna Provalenko
Phone: 704-587-8564
E-mail: dlprovalenko@mmm.com
Website: www.3M.com/Membrana

3M brings over 30 years of industrial membrane expertise in ultrafiltration and dissolved gas control applications. 3M™ Liqui-Flux™ Ultrafiltration modules take advantage of a pressure-driven out flow design with optimized backwash performance. 3M™ Liqui-Cel™ Membrane Contactors are compact and modular devices that control dissolved gases in liquids.

ADI SYSTEMS

Booth: 524
Contact: Mihalis Salmatanis
Phone: 800-561-2831
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Website: www.adisystemsinc.com

ADI Systems' extensive portfolio of proven anaerobic and aerobic treatment technologies reliably treats industrial wastewater. With over 35 years of experience and over 260 full-scale installations worldwide, our team can customize the most efficient treatment solution for each application. ADI Systems also offers technology to capture, treat, and utilize biogas as a source of renewable energy—helping save money and the environment. Design/build project delivery and technology packages are available for customers worldwide.

ADVANCED SENSORS LIMITED

Booth: 510
Contact: Duane Germenis
Phone: 281-433-5002
E-mail: duane.germenis@paclp.com
Website: www.advancedsensors.co.uk

Advanced Sensors is the leading global supplier of Oil in Water analyzers to the Oil and Gas Industries. We provide innovative solutions that guarantee our analyzers are self-cleaning, reliable and durable. We combine technologies such as ultrasonics, fluorescence and video microscopy to ensure analyzers stay clean and provide precise readings.

AECOM

Booth: 120
Contact: Karen Campbell
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E-mail: karen.campbell@aecom.com
Website: www.aecom.com/markets/water/

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital.

AMERICAN WATER CHEMICALS, INC.

Booth: 209
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Website: www.membranechemicals.com
American Water Chemicals, Inc. (AWC) manufactures specialty chemicals for pretreatment and maintenance of reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF) membrane systems. AWC is an international ISO 9001:2008 certified company specializing in chemical solutions and advanced analytical services for membrane separation processes and serves clients around the world. AWC has pioneered advanced membrane autopsy techniques and investigative services and supports both public and private business sectors. Our passion is to improve membrane system performance and optimize cost of operation by diagnosing and solving complex operational problems.

AMSA, INC.

Booth: 204
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Website: www.amsainc.com
AMSA, Inc. manufactures BCP™ chemistry (including DTEA II™) which functions as an organic deposit cleaner, penetrant aide and dispersant. BCP™ products provide a Biofilm Control Program when used with a biocide. Incorporating BCP™ chemistry in a typical acidic, scale and corrosion one-drum formulation provides scale & deposit control, plus the full benefits of DTEA II™.

AQUATECH INTERNATIONAL CORP.

Booth: 202
Contact: Michael Berger
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E-mail: bergerm@aquatech.com
Website: www.aquatech.com
Aquatech is a leading global provider of industrial and infrastructure water treatment solutions and services. Primary product groups offered by Aquatech include raw water treatment, ion exchange, membrane processes, wastewater recycle/reuse, zero liquid discharge, industrial concentration, and desalination systems. Over the past 35 years, Aquatech has executed over 1000 projects in more than 60 countries for the power generation, chemical, petrochemical, pharmaceutical, microelectronics, and other industries. Aquatech, through its subsidiaries and offices, has global sourcing and fabrication capabilities to suit logistics of project sites throughout the world.

ATHLON SOLUTIONS

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E-mail: samir.shah@athlonsolutions.com
Website: www.athlonsolutions.com
Athlon Solutions provides specialty water and process treatment chemicals, customized engineering solutions, and services to the industrial sector, including the refining, petrochemical, chemical, fertilizer, and power industries. We treat the equipment, not just the water.Our name is new, but our experience isn't. Through our parent company, we have provided chemicals and solutions for more than 65 years. We serve five of the 15 largest refineries and more than 70% of the U.S. ammonia plants.

ATLANTIUM TECHNOLOGIES,LTD.

Booth: 519
Contact: Dennis Bitter
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Website: www.atlantium.com
Atlantium's revolutionary and patented HOD™ technology will deliver a "real" dose , 100% of the time, with less energy and equipment. All other UV sciences delivers an "average" dose with significantly more equipment. HOD™ UV minimizes the inefficiencies of dose delivery and increases the UV effectiveness. Through this advanced science, HOD™ UV has validations and acceptance's not seen by any other UV technology. HOD UV has over 60 patents.

AVANTECH, INC.

Booth: 311
Contact: Dave Malkmus
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E-mail: dmalkmus@avantechinc.com
Website: www.avantechinc.com
AVANTech, Inc., along with its division in Knoxville, TN (previously DTS), provides turnkey water processing services and systems and also manages/processes low-level radioactive and hazardous wastes. Technologies include demineralization, polymer solidification, filtration, ultrafiltration, reverse osmosis, dewatering, and drying. These are applied on a stand-alone basis, or combined to effect waste stream or pool cleanup, sludge collection, silica removal, boric acid recovery, and zero environmental release. AVANTech also provides underwater systems and select ion specific media.

AVISTA TECHNOLOGIES, INC.

Booth: 106
Website: www.avistatech.com
Avista Technologies is a trusted expert in membrane system chemistry and global process support for Reverse Osmosis and Micro/Ultra Filtration membrane systems and Multimedia Filtration. Reverse Osmosis products include: Vitec® antiscalants, RoClean and AvistaClean® membrane cleaners and RoCide® biocides. A Green line of proven antiscalants and cleaners are free of phosphate, phosphonate, and EDTA. AvistaClean® MF are one-step cleaners formulated to restore MF/UF membrane performance when generics are no longer effective. Technical and laboratory services are available to help improve system

BAKER HUGHES - PROCESS AND PIPELINE SERVICES

Booth: 316
Contact: David Fulmer
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The Baker Hughes Downstream Chemicals group's programs and services address processing, water management, and finished product quality challenges in petroleum refining. We reduce cost by addressing needs and designing, implementing, and monitoring specialty chemical treatment programs that improve profitability and reliability. Offerings include process emulsion breaking, corrosion, fouling, and foam-control technologies. Plus, we have programs for treating and managing cooling water, boilers, raw water, and wastewater treatment.

BLUMETRIC ENVIRONMENTAL INC.

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BluMetric delivers sustainable solutions to complex environmental issues, serving clients across many commercial, industrial, institutional and public sectors, throughout the Americas and globally. BluMetric has deep-domain experience in the design, manufacture, installation, commissioning and operation of engineered water and wastewater treatment solutions for both simple and extremely complex applications. The goal of any project is to satisfy each client's environmental needs in the most technically appropriate and cost effective manner.

BOWEN ENGINEERING CORPORATION

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Bowen is a national self-performing EPC contractor in the water, wastewater, energy and industrial markets. From concept development to commissioning we serve private, investor owned, and municipal clients to deliver their high quality water projects on time, on budget and safely. It is our people who make us the most Resourceful, and Responsive and Result focused construction company to build CCR, ELG, Phy-chem, and other process water projects. Stop by our booth to meet our team.

BRENNTAG NORTH AMERICA

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Brenntag Water Additives your partner in Solutions for Industrial, Commercial and Municipal Water Treatment. Experienced and dedicated team members apply knowledge from Brenntag's global network to meet local needs. Brenntag is a full line chemical distributor with over 160 stocking locations in the US and Canada. Our broad product line includes coagulants, flocculants, biocides, scale inhibitors, corrosion inhibitors, defoamers, permanganates, filtration media, NSF certified products and facilities, as well as products for heavy metal removal and odor control. Source from the experts! Contact Brenntag today to learn how we can be your trusted partner in delivering quality chemicals safely, and on time.

BUCKMAN NORTH AMERICA

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Buckman offers an optimal solution for water treatment – an extensive portfolio of specialty chemicals, unmatched technical expertise and service, and a global network of experienced associates to help your operation become more efficient, effective and sustainable.

BURKERT FLUID CONTROL SYSTEMS

Booth: 525
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Burkert Fluid Control Systems is a global system solution provider in the water treatment industry. Our focus is on reliabilityand innovation, with the goal of creating lasting and effective results for the customer. Our manufacturing expertise encompasses process control and automation in a consultant system minded approach. We bring this wide range of knowledge to the water treatment industry for the purpose of offering: improved automation, accuracy and safety for processes within the industry. Aiding our customers in areas of desired improvement is our goal.

BURNS AND MCDONNELL ENGINEERING COMPANY, INC.

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Burns & McDonnell is a full-service engineering, architecture, construction, environmental and consulting firm. Our over 5,000 employee-owners are comprised of engineers, architects, construction experts, planners, estimators, technicians and scientists. We plan, design, permit, construct and manage facilities all over the world, with one mission in mind: Make our clients successful.

CENTRISYS CORPORATION

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Centrisys is a U.S.A. manufacturer of dewatering and thickening centrifuges, as well as complete dewatering systems for municipal and industrial wastewater. The Centrisys team focuses on centrifuge technology. This includes the award winning sludge thickening centrifuge THK series, 2- and 3-phase technologies and custom design for dewatering and thickening solutions. Centrisys provides global service, repair and parts for all brands of centrifuges. The Centrisys team is known for their process optimization expertise and hands on approach to find the most efficient dewatering solutions, giving customers the results they need.

CHEMTRAC, INC.

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Chemtrac designs and manufacturers instrumentation for monitoring critical water treatment applications. Their online particle counters detect insoluble particulate at low ppt levels, and are used for continuous corrosion product transport monitoring in the steam cycle, as well as for RO pretreatment filter performance monitoring and system optimization. Chemtrac is a global leader in providing streaming current charge measurement technology for coagulant feed control, and offers online analyzers for chlorine, ozone, pH, ORP, and organics monitoring.

CHEMTREAT, INC.

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ChemTreat is one of the world's largest providers of water treatment products & services. We develop customized programs with sustainable solutions to improve operating efficiencies, minimize expenditures, reduce carbon footprints, and improve energy and water management delivered through the most experienced sales and service team in the industry.

DANFOSS A/S HIGH PRESSURE PUMPS

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Danfoss High Pressure Pumps is a global leading supplier of high-pressure pumps (APP) and energy recovery devices (iSave) for SWRO applications - landbased, marine, offshore and mobile/containerized applications.The axial piston pumps are among the most reliable and energy-efficient on the market. The pumps are compact and easy to maintain. The isobaric energy recovery devices provide up to 95% efficiency. Flexible and compact, iSave ERDs are as easy to install as they are to operate.

DMP CORPORATION

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Taking The Worry Out of Wastewater! DMP is the premier provider of integrated wastewater treatment solutions. For 45 years, we have provided 100% commitment to our clients' continued success because we are singularly focused on providing exceptional industrial wastewater treatment solutions with the best possible people, state-of-the-art techniques and technologies, outstanding service, and an industry-first Performance Guarantee. Regardless of the type, difficulty or urgency or your wastewater challenge, DMP can help you solve it.

DOW WATER AND PROCESS SOLUTIONS

Booth: 301/303
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The global leader in sustainable separation and purification technology, Dow Water & Process Solutions is making real progress in the world. Dow is helping make water safer and more accessible, food taste better, pharmaceuticals more effective and industries more efficient and spearheading the development of sustainable technologies that integrate water and energy requirements. Dow Water & Process Solutions offers a broad portfolio of ion exchange, reverse osmosis, ultrafiltration, and high-solids filtration technology.

EISENMANN CORPORATION

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Eisenmann is a leading global industrial solutions provider for surface finishing, material flow automation, thermal process technology and environmental engineering. The company designs and builds flexible, energy- and resource-efficient systems that are tailored to customer requirements, and support state-of-the-art manufacturing and intralogistics.

EVOQUA WATER TECHNOLOGIES

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Evoqua is the global leader in helping municipalities and industrial customers protect and improve the world's most fundamental natural resource: water. We have a more than 100-year heritage of innovation and industry firsts, market-leading expertise, and unmatched customer service. Our cost-effective and reliable treatment systems and services ensure uninterrupted quantity and quality of water, enable regulatory and environmental compliance, increase efficiency through water reuse, and prepare customers for next-generation demands

FEDERAL SCREEN PRODUCTS, INC.

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FEDERAL SCREEN PRODUCTS manufactures Wedge Wire screen and fabricated Wedge Wire products for straining, screening, filtering and media retention in water purification, conditioning and waste water equipment. Federal Screens takes pride in their high quality products, reliable customer service, prompt deliveries and competitive pricing.

FILTRAFINE CORPORATION

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Filtrafine Corp is a worldwide leader in the design and manufacture of disposable filter cartridges, filter bags and filter housings. Filtrafine has developed an in depth understanding of how its filtration products provide critical benefits in a wide array of applications by working closely with its customers to improve processes and products. Filtrafine's main expertise lies in the designing and manufacturing of filter cartridges, bags filters and housings. With extensive and solid experience designing and producing pressure vessels we specialize in the manufacturing of pressure vessels according to Pressure Equipment Directive (92/23/EC) and ASME Boiler and Pressure Code. Our filter materials are FDA compliant with more established products bearing NSF and RoHS certification.

FILTRA-SYSTEMS COMPANY

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Filtra-Systems Company, LLC is a Tribally Owned Filtration Process Systems specialist, owned by Chickasaw Nation Industries. We offer a wide range of process specific solutions to our customers. We serve a diversified customer base in the Mining, Power, Chemical, and Oil & Gas Industry. Customized Engineering & Design, Turn-Key Fabrication, and Complete Process Solutions are the core capabilities of our organization. Filtra-Systems home office is located in Farmington Hills, Michigan, with fabrication and testing facilities in Tennessee and an ASME Code Certified MBE facility in Marietta, Oklahoma.

FLUIDRA USA

Booth: 516
Contact: Carme Marine
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E-mail: cmarine@fluidra.com
Website: www.fluidra.com
Fluidra USA manufactures pressure filters in fiberglass reinforced polyester and belongs to Fluidra group. Thanks to the large production capacity of 4 facilities in Spain and one in U.S., we design filters according to customer's specifications and produce equipment's of different sizes, connections and internal components. They are suitable for mechanical, activated carbon and biological filtration, ion exchange, denitrification or demineralization.

FRENCH CREEK SOFTWARE, INC.

Booth: 315
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Website: www.frenchcreeksoftware.com
French Creek develops and markets software tools for professional water treatment chemists and engineers including industry standard WaterCycle® for cooling water, WatSIM™ for municipal water including Pb and Cu minimization, hydROdose® for membrane systems, Downhole SAT® for oil field brines and flow back systems, and MineSAT™ for process waters. Water Reuse Suites combine programs and allow iterative optimization of water usage within a facility. All program series include model scale potential, corrosion, and inhibitor optimization. Each series include version optimized for end users, field engineers and water treatment salesman, marketing staff, and researchers. Private label versions, Windows® DLL's, and static UNIX® libraries available. French Creek Labs develop models for scale and corrosion, and their inhibition. French Creek - serving the water treatment industries since 1989.

FRONTIER WATER SYSTEMS, LLC

Booth: 218
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E-mail: admin@frontierwater.com
Website: frontierwater.com
Frontier Water Systems develops, designs, and manufactures specialty engineered equipment for the targeted removal of selenium, nitrate, arsenic and mercury from water and wastewater associated with power generation and mining. Frontier Water's systems employ patent pending and proprietary biological treatment processes, which provide unparalleled efficiency in terms of equipment footprint and water quality. We continue to build upon the most applied experience in effective and practical industrial biological solutions though a culture of collaboration and innovation. Our advances in biological metals removal technology are saving heavy industry hundreds of millions of dollars today, while providing the cleanest water possible to our lakes and rivers.

GE POWER, WATER & PROCESS TECHNOLOGIES

Booth: 416/418
Contact: Jay Harwood
Phone: 905-379-3958
E-mail: James.Harwood@ge.com
Website: https://www.gewater.com/
With operations in 130 countries and employing over 7500 people worldwide, GE's water & process technologies leverages our innovation, expertise and global capabilities to solve our customers' toughest water and process challenges wherever they occur. As a strategic business partner, GE offers a comprehensive set of chemical and equipment solutions, as well as predictive analytics to enhance water, wastewater and process productivity. Visit www.gewater.com to learn more.

GENESYS INTERNATIONAL, LTD.

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Website: www.genesysro.com
Genesys International is an industry leader in the development and manufacture of specialty membrane antiscalant and cleaning chemicals for RO/NF and UF systems. Since 2001 we have built a team of industry experts and a global network of distributors delivering our products and services world-wide. Innovations include:

- GENAIRCLEAN™ a revolutionary method for membrane cleaning incorporating micro-bubbles and effervescent reagents to enhance deposit removal.
- MEMBRANE MASTER 4™, antiscalant prediction software. Genesys North America is actively looking for new partners and distributors in the US.

GLOBAL CHEM-FEED SOLUTIONS

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Fax: 215-675-0895
E-mail: donc@globalchem-feed.com
Website: www.globalchem-feed.com
Global Chem-feed Solutions (GCS) is a supplier of custom skid mounted chemical feed systems as well as wet dust suppression systems for Electric Generating, Hydrocarbon Petrochemical and other Heavy Industrial Manufacturing facilities. These custom products are engineered for the injection of chemicals into boiler water, cooling water, and waste water systems, as well as a wide variety of process applications. Additionally GCS manufactures Ammonia Storage Tank and Transfer pump systems as well as Truck Unloading Stations and Chlorination Systems.

GLOBAL TREAT, INC.

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Fax: 281-370-3425
E-mail: info@globaltreat.com
Website: www.globaltreat.com
Global Treat, Inc. was established in Houston, Texas in 1994. We are a provider of equipment for drinking water, wastewater, and cooling towers. In addition, we provide chlorination chem feed packages for gas, evaporators, liquid, tablet and generators. We provide acid dilution troughs, chemical diffusers, chlorine analyzers, gas detectors, automatic valves, fiberglass shelters, and chemical scales.

GOLDER ASSOCIATES

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GRAVER WATER SYSTEMS/ECODYNE WATER

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Graver Water Systems and Ecodyne Water are both units of the Marmon Industrial Water Group. We design and manufacture water, wastewater, and condensate polishing systems for the utility, petroleum, and industrial market. Our engineers and process experts are experienced in the design and supply of high quality systems for pre-treatment, membranes, ion exchange, deaeration, waste treatment, condensate polishing, cooling water treatment, and oil/water separation. We can provide both custom designed and modified standard design equipment.

GRUNDFOS NORTH AMERICA

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Website: www.grundfos.us
Grundfos is committed to delivering innovative products that ensure the efficient management of water. Pumps currently account for 10 percent of global electricity consumption – Grundfos works to reduce that number that by manufacturing the most efficient and technologically advanced products on the market. High on the company's corporate agenda is an active commitment to improving the environment. Grundfos contributes to global sustainability by pioneering technologies that improve quality of life for people and care for the planet.

HACH COMPANY

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Hach is committed to providing solutions for better management and testing of water quality by offering high-quality products that are simple to use and accurate. Our analytical instruments and reagents are used to test water quality in a variety of industries and markets around the globe. Water analysis has to be right. You deserve complete solutions you can be fully confident in. Hach is your resource for expert answers, outstanding support, and reliable, easy-to-use products.

HONEYWELL PROCESS SOLUTIONS/UOP

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HOWDEN ROOTS

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IDE TECHNOLOGIES

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IDE is a world leader in water treatment solutions, specializing in the development, engineering, construction and operation of some of the largest and most advanced desalination; industrial water treatment and water reuse plants. IDE works in partnership with a wide range of customers on all aspects of water projects, delivering 3 million m3/day of high quality water worldwide. IDE brings technological leadership, proven reliability and consistent delivery to all our customers.

ILLINOIS WATER TECHNOLOGIES

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Illinois Water Technologies is an aftermarket service provider for water purification equipment. We also provide aftermarket replacement parts. Illinois Water Technologies also provides design and fabrication services for original equipment manufactures.

ITOCHU CHEMICALS AMERICA INC.

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ITOCHU Chemicals America, Inc. Exclusive distributor of ION EXCHANGE RESINS, manufactured by Mitsubishi Chemicals, for use in separation and purification processes in the food, beverage, water & biochemical and pharmaceutical industries. Exclusive distributor for Quantum DMI-65 Iron and Manganese filtration media.

JACOBI CARBONS, INC.

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Jacobi Carbons is one of the leading global activated carbon manufacturers that has expanded into the ion exchange resin market place. Resinex is the division of Jacobi Carbons that offers a complete portfolio of high quality ion exchange resins. This division includes hundreds of different ion exchange, adsorbent, and catalyst type products for a variety of applications. Jacobi and Resinex continue to be on the leading edge of carbon and resin technology by adding more products to solve unique applications every day.

JOHNSON MARCH SYSTEMS, INC.

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Johnson March Systems, Inc. is a custom designer and fabricator of Chemical Dosing Systems for Water Treatment and Process Additive Applications. JMSI also designs and fabricates Steam and Water Sampling Panels, Ammonia Feed Systems for NOx Reduction, Electrolytic Chlorination Systems, Gaseous Chlorination Systems, and Dust Suppression Systems. Many systems are supplied in Shelters We supply to the Power, Petrochemical, Wastewater and various Heavy Industries worldwide. JMSI is ASME Certified and ISO 9001-2008 certified by Underwriter Laboratories. Johnson March started in 1935.

JUSTEQ, LLC

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LANXESS SYBRON CHEMICALS INC.

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LECHLER INC.

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METTLER TOLEDO PROCESS ANALYTICS

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METTLER TOLEDO Thornton is a leader in pure and ultrapure industrial water monitoring instrumentation used in power and microelectronic applications. Thornton's leading market position is demonstrated by its innovative analytical instruments and sensors for the measurement parameters of conductivity & resistivity, TOC, (optical) dissolved oxygen, sodium, silica, Degassed Conductivity, and pH in a variety of cycle chemistry and make up water applications. Thornton innovation continues with the introduction of the 3000CS analyzer for on-line chloride and sulfate measurement.

MPW INDUSTRIAL SERVICES

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NALCO WATER, AN ECOLAB COMPANY

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NEPTUNE CHEMICAL PUMP CO. / FLUID DYNAMICS

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Neptune is a manufacturer of chemical metering pumps, portable mixers and chemical feed systems. Neptune offers a full line of water treatment products including bypass feeders, filter feeders, sample coolers, injection quills and corporation stops. Neptune designs and builds semi-custom and custom chemical feed systems for boiler and cooling tower water treatment. Fluid Dynamics is a manufacturer of both liquid and dry polymer make down systems.

OASYS WATER

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OLI SYSTEMS, INC.

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OVIVO USA

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PARKER HANNIFIN WATER PURIFICATION

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PARKSON CORPORATION

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Booth: 319
Contact: Jim Mitchell
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PROCESS SOLUTIONS, INC. - A UGSI SOLUTIONS COMPANY

Booth: 210
Contact: Jerry Scott
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E-mail: jscott@ugsicorp.com
Website: www.4psi.net
Process Solutions, Inc. (PSI) is the leader in on-site hypochlorite (bleach) generation for water disinfection. Microclor® on-site hypochlorite generation products have been installed in hundreds of locations with capacities from 20 lbs/day to cover 6,000 lbs/day of chlorine equivalent. The PSI Monoclor™ system combines world class tank mixing with a cutting edge chloramine management system to reliably manager disinfectant residual levels in tanks and reservoirs.

PROCHEM, INC.

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PROMINENT FLUID CONTROLS, INC.

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ProMinent Fluid Controls, Inc. is a global manufacturer of chemical metering pumps and systems, process instrumentation, dry and liquid polymer systems, disinfection equipment, and custom packaged feed systems. We have proudly served the Municipal, Industrial and OEM markets in the United States for over 35 years.

PROTEC-ARISAWA AMERICA

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Protec-Arisawa is the leading RO pressure vessel manufacture in the USA. We have produced pressure vessels for the municipal, industrial, commercial and residential market since 1999 in our 65,000 square foot manufacturing facility in Vista, California. With a long history of producing RO vessels we have design engineering, process engineering and manufacturing all in our facility. As part of the ARISAWA group, we also manufacture RO vessels in our facility in Mungia, Spain and in Japan. All PROTEC ARISAWA vessels are designed to the exacting ASME Boiler and Pressure Vessel Code section X for filament wound vessels. ASME code stamps are available at a nominal additional charge. We produce vessels from 4" diameter through 16" diameter with pressure ratings of 300 psi, 600 psi, 450 psi, 1000 psi and 1200 psi. Standard lengths are also available from single element to eight element length. Please contact Richard Chmielewski, P.E. at 760-599-4800 for more information

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PWT & PIEDMONT

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PWT Chemical manufacturing and supply for the membrane industry, with a product line developed around unique dendrimer-based antiscalant chemistry for scale and fouling control. PWT have also developed solutions and services to support their customers who are addressing varied and difficult applications like seawater desalination and wastewater re-use. Piedmont (www.piedmontpacific.com/)Piedmont Pacific is a global leader in corrosion resistant equipment for desalination plants and meets critical customer demand for a wide range of applications in the industrial and municipal markets.

QUA GROUP, LLC

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QUA is an innovator of advanced membrane technologies that address the most demanding water purification requirements. Headquartered in the USA, QUA provides its OEM partners with best practices in R&D, innovation, quality, and customer service. QUA's diverse product portfolio includes fractional electrodeionization technology (FEDI®), polymeric (Q-SEP®) and ceramic (CeraQTM) ultrafiltration membranes, and submerged membrane bioreactor modules (EnviQ®). These products are specifically designed for high purity water treatment, wastewater recycle/reuse, seawater desalination, and potable water purification applications.

REAL TECH, INC.

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SCHREIBER LLC

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Serving Industrial & Municipal markets since 1979, Schreiber LLC solves wastewater treatment problems through the application of energy-efficient, innovative, and proprietary equipment/process technology. Schreiber offers a complete system from head works to tertiary filtration. Our patented treatment processes such as the Continuous Sequencing Reactor® and compressible media filter "Fuzzy Filter®" combine effectiveness and efficiency to produce the industry's highest quality products. The "Fuzzy Filter®" is an adjustable pore size filter to 4 microns that operates at 5 times the rate and uses 1/4 the wash water of granular media filters.

SENTRY EQUIPMENT CORP.

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SHANDONG TAIHE WATER TREATMENT CO.

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Shandong Taihe Water Treatment Technologies Co., Ltd. is the largest professional manufacturer of water treatment chemicals in China, with sales volume being No. 1 for years. Taihe focuses on manufacturing and devotes itself to be the production workshop for global water treatment industry. The turnover has reached USD 162 million with sales volume of 127,700 MT in 2014. Taihe's new project of 300,000 MT water treatment chemicals in Zhongtai Chemical Zone have been put into production.

SOLENIS LLC

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Solenis is a leading global manufacturer of specialty chemicals for the pulp, paper, oil and gas, chemical processing, mining, biorefining, power and municipal markets. The company's product portfolio includes a broad array of process, functional and water treatment chemistries as well as state-of-the-art monitoring and control systems. These technologies are used by customers to improve operational efficiencies, enhance product quality, protect plant assets and minimize environmental impact. Headquartered in Wilmington, Delaware, the company operates 30 manufacturing facilities strategically located around the globe and employs a team of 3,500 professionals in 118 countries across five continents. For additional information about Solenis, please visit www.solenis.com.

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STENNER PUMP COMPANY

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SUMITOMO ELECTRIC INDUSTRIES, LTD.

Booth: 509
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Phone: 408-300-3968
E-mail: kyasui@sumitomo.com
Website: www.sumitomoelectricusa.com/poreflon/
Sumitomo Electric Industries provides wastewater treatment solutions with proprietary hollow fiber MF/UF membranes made of PTFE (Polytetrafluoroethylene). The membranes are robust and tough, having excellent thermal and chemical stability. The membranes are tolerant to high content of oil in feed water, enabling to treat oily wastewater without pre-treatments. Those are ideal solutions to industrial wastewater treatment applications including oil & gas, mining, power, food & beverage and others.

SWAN ANALYTICAL USA

Booth: 501
Contact: Dominic O'Donnell
Phone: 847-229-1290
Fax: 847-229-1320
E-mail: info@swan-analytical-usa.com
Website: www.swan-analytical-usa.com/
Swan Analytical manufactures online continuous monitoring analytical instruments for high purity water, and potable water. Measurements include trace sodium, trace silica, trace Dissolved Oxygen, Conductivity/Resistivity, pH/ORP, phosphate, nitrate, ammonium, hydrazine, TOC, chlorine, bromine, fluoride and turbidity. Swan's analyzers deliver high precision with ease of operation.

TAYLOR TECHNOLOGIES

Booth: 317
Contact: Chris Golden
Phone: 800-837-8548
E-mail: chris@taylortechnologies.com
Website: www.taylortechnologies.com
An ISO 9001:2008-certified manufacturer, Taylor Technologies has produced reliable, reasonably priced water-testing supplies for industrial water treaters since 1930. Offerings include the field-tested TTi® 3000 Colorimeter, as well as test kits, reagents, standard solutions, labware, and electronic meters. The TTi 3000 comes preprogrammed to test 30+ water quality parameters most encountered in commercial/industrial settings, lifetime free upgrades, and a 5-year warranty. Its portability and data-logging capabilities make this device suitable for field or laboratory use.

TECHNOFORM KUNSTSTOFFPROFILE GMBH

Booth: 320
Contact: Norbert Scherer
Phone: 49-561-95839-86
Fax: 49-561-95839-21
E-mail: nscherer@tkp.biz
Website: www.tkp.biz

Technoform Kunststoffprofile (TKP) is a subsidiary of the Technoform Group, which is market leader in the extrusion of technical thermoplastics. Processing of materials with high amounts of fillers enables TKP to introduce plastic tubes to industries, where plastic products have not been widely used before. The extrusion specialist designed heat exchanger tubes for wastewater applications, which combine a good corrosion resistance with a high heat transfer coefficient. They can fully compete against metal tubes.

THERMAX, INC.

Booth: 515
Contact: Ajit Dighe
Phone: 248-921-0779
Fax: 281-600-1336
E-mail: ajit@thermax-usa.com
Website: www.thermaxglobal.com
Thermax Inc is part of Thermax Group , a Company providing a range of engineering solutions to the energy and environmental sectors of our global market. We operate globally through 19 International offices , 12 Sales and Service offices , and 11 manufacturing facilities, 7 of which are in India and 4 overseas. Our Ion Exchange Resin Division falls under our Chemicals portfolio. Thermax Chemicals is one of the leading manufacturers of a gamut of TULSION brand Ion Exchange Resins for more than 35 years. TULSION is a premium brand and enjoys a global reputation in the field of water treatment and process application technologies.

TRISEP CORPORATION

Booth: 518
Contact: Lyndsey Wiles
Phone: 805-455-0560
Fax: 805-964-1235
E-mail: lwiles@trisep.com
Website: www.trisep.com/
TriSep Corporation will soon be a part of Microdyn-Nadir. Together, our mission is to deliver superior membrane-based solutions for challenging liquid separations. We offer the widest range of membrane products including MF, UF, NF and RO in flat sheet, spiral-wound and hollow-fiber configurations. TriSep will continue delivering customized products to solve customers' unmet needs and will soon be offering the technologically advanced BIO-CEL® MBR, along with the RO elements to purify the effluent for reuse.

TURNER DESIGNS HYDROCARBON INSTRUMENTS, INC.

Booth: 226
Contact: Chip Westaby
Phone: 559-253-1414
Fax: 559-253-1414
E-mail: sales@oilinwatermonitors.com
Website: www.oilinwaters.com
Turner Designs Hydrocarbon Instruments, Inc. is the worldwide leader in the application of field portable, laboratory, and online continuous process monitors for measuring and monitoring hydrocarbons in water. Our monitors are exclusively based in UV and visible fluorescence technology.

U.S. WATER SERVICES

Booth: 425
Contact: Don Lonsert
Phone: 866-663-7633
Fax: 763-553-0613
E-mail: don.lonsert@uswaterservices.com
Website: www.uswaterservices.com
U.S. Water gets to the root cause of problems to eliminate them at their source by utilizing an integrated water management approach that combines engineering, equipment, chemicals and services. We help industries find cost-effective and environmentally friendly solutions for their most challenging water, energy and compliance problems. Our customer focused approach enables our staff to work as an extension of your team making your goals our goals so you can focus on what's important – running your facility.

UNIVAR

Booth: 217
Contact: John Fulcher
Phone: 855-888-8648
E-mail: watertreatment@univar.com
Website: www.univar.com
Univar is a leading global distributor of specialty and basic chemicals from more than 8,000 producers worldwide. With a broad portfolio of products and innovative services, and deep technical and market expertise, Univar delivers the tailored solutions customers need through one of the most extensive chemical distribution networks in the world. Univar is Chemistry Delivered(SM).

USP TECHNOLOGIES (FORMERLY U.S. PEROXIDE)

Booth: 305
Contact: Nina McLendon
Phone: 404-352-6070
Fax: 404-352-6077
E-mail: info@usptechnologies.com
Website: www.usptechnologies.com/
For more than 20 years USP Technologies, formerly US Peroxide, has been providing cost-effective, peroxygen-based technologies and full-service chemical treatment programs for municipal and industrial water and wastewater applications. Our programs provide low-risk, value-added solutions to customers. We successfully integrate storage equipment, customized dosing control, chemical supply, inventory and logistics management, and ongoing equipment and applications support.

VEOLIA WATER TECHNOLOGIES

Booth: 302
Contact: Renee Look
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E-mail: renee.look@veolia.com
Website: www.veoliawatertech.com
Veolia Water Technologies specializes in technological solutions and provides the complete range of services required to design, build, maintain, and upgrade water and wastewater treatment facilities for industrial clients and public authorities.

WATERCOLOR MANAGEMENT

Booth: 208
Contact: Karen Seals
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Fax: 256-355-3070

E-mail: karen@watercolormanagement.com
Website: www.watercolormanagement.com/
WaterColor Management is the original insurance organization that has provided risk management support to companies and professionals in the water treatment industry since the AWT was founded in 1986. We now offer, in partnership with an A++ XV rated company, the broadest-available insurance coverages for water treaters, manufacturers, suppliers and consultants in the industry. Our coverages are specifically tailored to meet the needs of our insureds.

WATERTECTONICS

Booth: 407
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Fax: 425-349-4890
E-mail: Denney.Eames@watertectonics.com
Website: www.watertectonics.com
Established in 1999, WaterTectonics designs, manufactures, deploys, and services advanced water treatment systems to help clients meet compliance with environmental permits or reduce operating costs related to water. The company offers innovative electrocoagulation technology in addition to chemical, media, and membrane-based systems. Supporting services include treatability studies, pilot systems, industrial design, field services and more.

WESTECH ENGINEERING, INC.

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Phone: 801-265-1000
Fax: 801-265-1080
E-mail: jwoods@westech-inc.com
Website: www.westech-inc.com
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WIGEN WATER TECHNOLOGIES

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E-mail: steve.mcsherry@wigen.com
Website: www.wigen.com
Since its inception in 1965, Wigen Water Technologies has become a leading manufacturer of custom water treatment systems. We specialize in application-specific, cost-effective and reliable solutions for industrial, municipal and ultrapure clients. WWT purifies water for manufacturers making cutting edge medicines, brand name food and beverage producers feeding the world, power districts providing electricity, hospital and university laboratories requiring re-agent grade water and semi-conductor/nanoscience fab floors at the cutting edge of technology.

WUNDERLICH - MALEC ENGINEERING, INC.

Booth: 108
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Phone: 920-241-0935
E-mail: brad.spindler@wmeng.com
Website: www.wmeng.com
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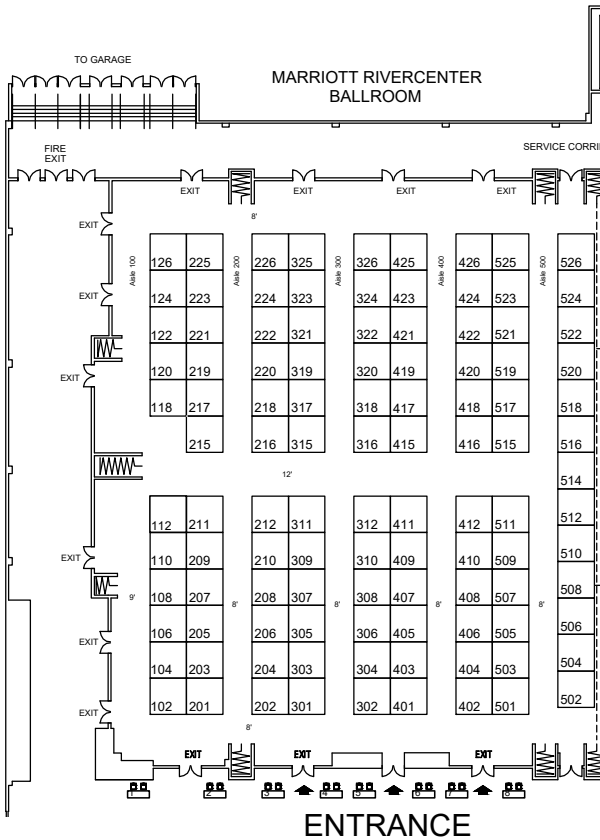

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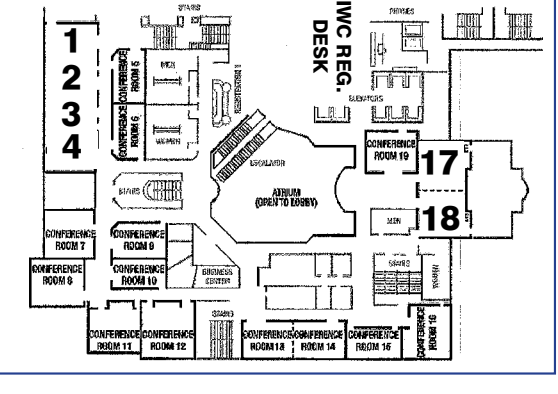

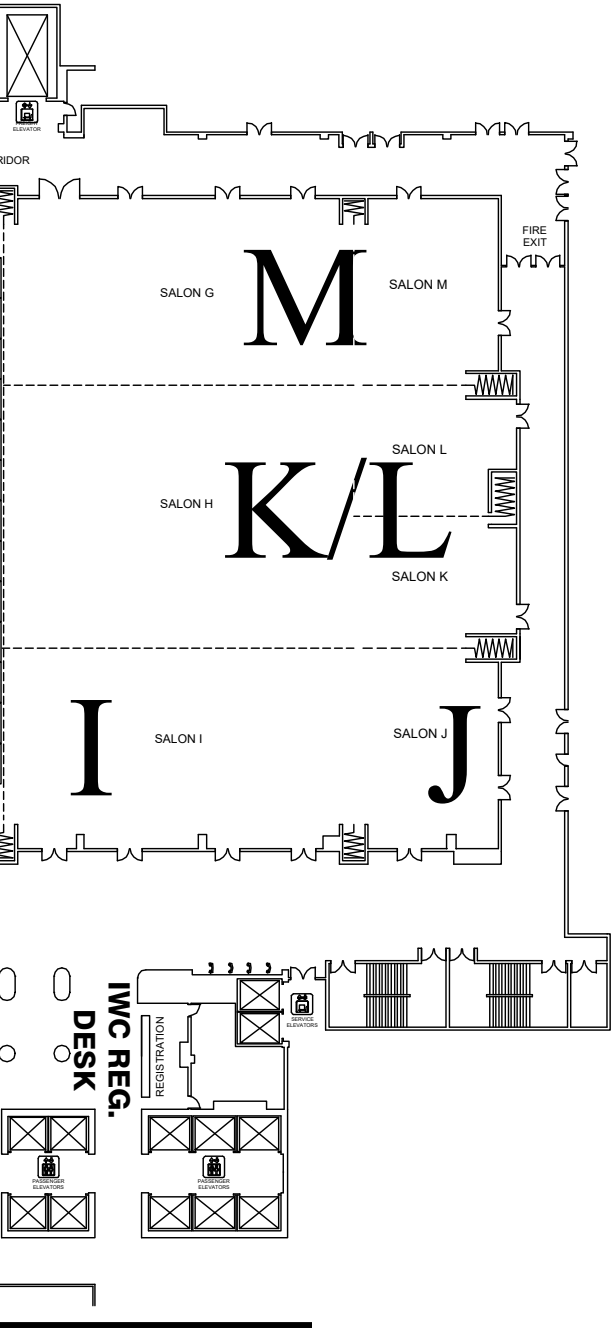
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