



Life of a Transformer™ Seminar

Get Empowered with Doble

February 19-23, 2018 | National Harbor, Maryland USA



Agenda is subject to change.

LEGEND

TP: Transformer Professional Program (M-TH)

TP -A: Transformer Professional Program - Advanced Training (W-TH)

TM: Transformer Maintenance Program (W, TH, F)

RP: Transformer Relay Protection Program (M-TH)

LS: Laboratory Seminar (F)

Note: There is no need to pre-register for particular sessions. Simply choose the session that's right for you.

Sunday, February 18, 2018

4:00 PM – 7:00 PM

Registration & Information Desk Open

Monday, February 19, 2018

6:30 AM – 6:00 PM

Registration & Information Desk Open

6:30 AM – 8:00 AM

Attendee Breakfast

TP &

RP 8:00 AM – 8:15 AM

Welcome & Introduction

Bryan Sayler, President

Doble Engineering Company

Bryan Sayler brings 28 years of experience developing and implementing highly engineered test solutions for wireless, EMC and microwave applications in the electronics, automotive and aerospace industries. Prior to joining Doble, Mr. Sayler was Sr. Vice President Solutions Development at ETS-Lindgren where he led global project management, hardware, software and strategic solutions development through active participation in global standards bodies including IEEE, CTIA, 3GPP and the WiFi Alliance.

TP &

RP 8:15 AM – 8:45 AM

Opening Keynote

J. Tyler Anthony, Senior Vice President and Chief Operating Officer

Pepco Holdings

J. Tyler Anthony has more than 31 years of experience in utility operations. His experience includes electric



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distribution, transmission operations, nuclear generation, project management, customer service and labor relations. He was appointed senior vice president and chief operating officer of Pepco Holdings in March 2016. Based in Washington, D.C., Pepco Holdings employs more than 4,700 people, owns more than \$16.1 billion in assets and generates approximately \$4.8 billion in annual revenues. Pepco Holdings serves 2 million customers as the parent company of Pepco, an electric utility serving Washington, D.C., and suburban Maryland; Delmarva Power, an electric and gas utility serving Delaware and the rest of the Delmarva Peninsula; and Atlantic City Electric, an electric utility serving southern New Jersey. Pepco Holdings is a recently acquired subsidiary of Exelon Corporation, one of the nation's leading energy services companies

Prior to his current position with Pepco Holdings, Mr. Anthony served as the senior vice president of distribution operations for Commonwealth Edison Company (ComEd) in northern Illinois, vice president of Transmission and Substation for ComEd and vice president of Projects for Exelon Nuclear.

TP &

RP 8:45 AM – 9:15 AM

Primer on Large Power Transformers

Jeff Short, Manager, Client Service Engineering

Doble Engineering Company

As we move forward into the 21st Century, the use of electricity by mankind has evolved into a necessary staple of everyday life. But it wasn't always this way. The advent of power transformers in today's world is a function of necessity, a product of ingenuity, and a marvel of technology. Power transformers are the key element in the present system of electrical power distribution, and this system could not function without transformers. Let's take a look at why and how they were developed.

9:15 AM – 9:30 AM

Break

TP &

RP 9:30 AM – 10:30 AM

Transformer Specification & Vendor Prequalification

Bill Griesacker, Principal Engineer

Doble Engineering Company

An effective procurement system utilizes the preapproval process to identify suitable power transformer vendors and a design review to establish an agreed upon design and procurement process. This preapproval approval process should include factory qualification audits which are essential to confirm a manufacturer's ability to meet a purchaser's requirements and expectations. The design review is performed to establish an agreed upon design and to facilitate the procurement process. That the supplier is capable of meeting the purchaser's procurement specifications is confirmed during this process and the procurement process is expedited by bringing the purchaser and supplier together on the technical details of the purchased transformer.

Bill Griesacker is a member of Doble Engineering Company as a transformer engineer working on projects that include factory inspections, condition assessment, design reviews, failure analysis and general consulting. He



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previously worked for Pennsylvania Transformer Technology Inc., where he held various positions including Engineering Manager. His work included high voltage insulation design, transient voltage modeling of power transformer windings and various LTC and DETC switch development projects. Prior to this, he was employed by the Westinghouse Electric Company, working on synchronous generator projects as a member of the Generator Engineering Department. Mr. Griesacker started his career with Cooper Power Systems in large power transformers and later worked in the Kyle Switchgear, Vacuum Interrupter Department. He has earned a MS in electric power engineering from the Rensselaer Polytechnic Institute and a BS in electrical engineering from Gannon University. Mr. Griesacker is an active member of the IEEE, PES Transformers Committee where he holds positions in several working groups and subcommittees.

TP &

RP 10:30 – 12:00 PM

Transformer Design & Manufacturing

Dharam Vir, Vice President of Engineering

Troy Kabrich, Vice President & General Manager – Services Division

SPX Transformer Solutions, Inc.

Transformers are tailor made products. The design process begins with understanding customer requirements. Using optimization programs a quote design is provided with the lowest total owning cost meeting customer requirements. During final design detailed dielectric, short circuit and thermal calculations are performed to ensure the transformer meets performance and customer requirements. The mechanical design of the tank, stiffeners, lifting and clamping structures enables the unit to withstand vacuum, pressure, short-circuit, seismic and shipping conditions. After completion of the design, production and fabrication drawings, designs are released for manufacturing. The presentation will review major operations in the manufacturing process including visual aids that show construction, testing, and shipping activities.

***Dharam Vir** joined SPX Waukesha in 2004 with over 25 years of service to the transformer industry in EHV design, testing, production and plant operations. Prior to his current position, he held the positions of Engineering Manager for the Waukesha plant and director of our EHV program, leading the team responsible for the Waukesha facility expansion. Mr. Vir is an active member of the IEEE Transformers Committee and holds a BSEE from University of Delhi India, a MS in Electrical Engineering from NIT Bhopal India and an MBA in Finance and Marketing from Bhopal University India.*

***Troy Kabrich** is currently the Vice President & General Manager for the Goldsboro, NC Manufacturing Plant and the Service and Components Division of SPX Transformer Solutions, Inc. During his twenty-five years of industry experience, Mr. Kabrich has held positions as a Plant Manager, Director of Field Services, Repair Operations Manager, Field Service Engineer, and Sales Engineer. He has published articles for T&D World and Utility Automation and Engineering magazines, was author of Installation and Maintenance Chapter of Third Revision of the Electric Power Transformer Engineering Handbook, and is a frequent contributor to industry training programs. Troy has a Bachelor of Science degree in electrical engineering from Rose-Hulman Institute of Technology.*

12:00 PM – 1:00 PM

Lunch



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TP &

RP 1:00 PM – 1:45 PM

Ensuring a Robust T&D System

David Roop, Director, Electric Transmission Operations & Reliability, Power Delivery Group

Dominion Energy

Utilities must maintain safety, reliability and resiliency among today's electric grid challenges from natural events (hurricanes, tornadoes, earthquakes, geomagnetic disturbances, polar vortex, etc.), man-made events (physical/cyber terrorism, electromagnetic pulse, copper theft, etc.) and changing location and mix of generation. This session discusses grid resiliency planning in times of rapid change to ensure a robust transmission and distribution system to meet customer expectations. Resiliency initiatives cost recovery issues in a transparent stakeholder process will also be discussed.

David W. Roop is currently Director of Electric Transmission Operations & Reliability in the Power Delivery Group. He is responsible for the operation of Dominion Energy's transmission assets, including substations in three states. Presently manages an organization that provides technical support and engineering resources for electrical equipment, protective relays and operations including research activities to support Transmission System development. He is an active member of CIGRE presently serving as the President of the CIGRE U.S. National Committee. He is currently a Senior Member of the IEEE and is a recipient of the IEEE Power Engineering Society, 2014 Leadership in Power Award.

TP &

RP 1:45 PM – 3:30 PM

Understanding Factory Testing Data

Mark Lachman, Director of Diagnostic Analyses

Doble Engineering Company

This presentation briefly describes significance of various electrical production tests including typical test plan covering all final factory tests as per IEEE C57.12.00-2015 and C57.12.90-2015. For each test the discussion includes physics behind the measurement, setup and test methodology and acceptance criteria.

Mark F. Lachman, Ph.D., P.E., has been with the power industry for over 30 years. In 2005, he joined Delta Star in San Carlos, CA, where, as Test Manager, he was responsible for the test department operation. In 2011, he returned to Doble Engineering Company as Director of Diagnostic Analyses.

3:30 PM – 3:45 PM

Break

TP &

RP 3:45 PM – 4:30 PM

Shell-Form Design & Construction

Dom Corsi, Senior Transformer Consulting Engineer

Doble Engineering Company



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Pedro Lima, Research and Development Senior Specialist
Efacec

Although transformers are typically referred to according to their role in a power system, they are also classified according to their construction: core-form or shell-form. This webinar will cover history and development of shell-form transformer designs in N. America and comparison of typical shell-form and core-form design features & construction, maintenance and diagnostic testing, and replacement consideration. Shell-form technology was developed by Westinghouse Electric Corporation and was licensed to a number of transformer manufacturers world-wide. The core-form technology was favored by General Electric. Traditionally shell-form transformers were commonly found in applications above 100 MVA and 230 kV such as generator step-up transformer, transmission autotransformer, shunt reactor, mobile substation and arc furnace transformer applications.

Dom Corsi has 27 years of experience in the manufacturing and electrical design of large power transformers. This experience includes both core and shell form designs. Mr. Corsi joined Doble in 2004 as a Transformer Consulting Engineer for Doble Global Power Services. In the last 12 years, he has concentrated on electrical power apparatus testing, condition assessment, and forensics. Additionally, he has designed transformers up to 400 kV and 570 MVA and reviewed or supervised transformer designs to 525 kV and 1100 MVA. His main interests are in the fields of power transformer design, and power transformer applications. A frequent presenter, Dom Corsi trains participants on many transformer related topics including Transformer Repair, Remanufacturing and Replacement, Transformer Design Review, Transformer Factory Inspections.

TP &

RP 4:30 PM – 5:15 PM

Insulating Materials Basics

Lars Schmidt, Technology Lead Center Manager – Insulation
ABB Inc.

This session offers an overview of power transformer insulation with a focus on cellulose based insulation materials. Both raw materials and the conversion of cellulose to transformer board will be discussed including environmental considerations. The main function of cellulose insulation in a power transformer will be covered and the electrical, mechanical, and aging properties of pressboard, pressboard laminate and laminated wood will be discussed.

Lars E. Schmidt is the Product Line Technology Manager for Transformer Insulation at ABB and located in Bad Honnef, Germany. He is responsible for the development of new insulation materials and manufacturing processes since 2011. ABB produces transformer insulation in different factories including Sweden, India, and Germany. Lars joined ABB Corporate Research in 2006 and worked in the field of polymer based medium and high voltage insulation. He has a background in Material's Science and holds a PhD from the Swiss Federal Institute of Technology, Lausanne.



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TP &

RP 5:15 PM – 5:45 PM

Ask the Experts Panel

6:00 PM – 8:00 PM

Industry Expo Opening & Reception

ABB and Delta Star will have heavy equipment on display during Industry Expo.

8:00 PM – 11:00 PM

Welcome & Networking Event POSE (Gaylord National Harbor)

All are welcome to attend the welcome event at the hotel's Pose nightclub, reserved exclusively for Life of a Transformer attendees, exhibitors and their guests. Sponsored by SPX Transformer Solutions, Inc., ABB, A-Line and Delta Star, this event includes desserts, drinks, views and good conversation with colleagues in a relaxed and casual atmosphere.



Tuesday, February 20, 2018

6:30 AM – 6:00 PM

Registration & Information Desk Open

6:30 AM – 8:00 AM

Attendee Breakfast

TP 8:00 AM - 9:45 AM

Transformer Type Designs

Autotransformers: Waldemar Ziomek, PTI Manitoba Inc.

Transformers for Renewable Resources: Israel Barrientos, GE Prolec

Mobile Transformers: Marion Jaroszewski, Delta Star

Generator Step-up Transformers: Mark Lowther, Mitsubishi

Autotransformers: When the primary and secondary voltages are obtained from the same winding, or from two windings which are galvanically connected, such a transformer is called an autotransformer. The autotransformer requires less turns than a two-winding transformer and this leads to a more economical design. The presentation will focus on fundamentals,



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design and applications of autotransformers. It will start with basic concept and typical winding arrangements. Next, the voltage variation will be addressed through presentation of different tap winding arrangement in the unit. Magnetic field distributions and resulting impedance at different tap positions will be shown. The selected problems of insulating system will be discussed (e.g. end fed vs center fed HV lead bring out, stresses in the end insulation). Examples of the lightning impulse voltage distributions for different winding arrangements will be shown.

Dr. Waldemar Ziomek works as Director of R&D for PTI Manitoba Inc (Winnipeg, MB, Canada), Canadian manufacturer of large power transformers. From 2013-2015 he worked for CG Power Systems, an international T&D equipment company, as a Global Senior Expert. Until 2013 he was employed by CG Power Systems Canada Inc. (formerly Pauwels Canada Inc.) as Manager of Engineering. He started with Pauwels in 1997 as Electrical Designer, then Electrical Engineering Manager, and since 2003 as Manager of Engineering. Dr. Ziomek has been an adjunct professor at The University of Manitoba since 2001. He published more than 60 technical and scientific papers. He is a member of IEEE, IEC, CSA and Cigre.

Transformers for Renewable Resources: This session addresses design considerations for step-up transformers connected to renewable energy sources, specifically solar and wind. Step-up transformers for renewable energy sources were selected, in the early days of the renewable energies land-grab, from run-of-the-mill distribution transformer designs that were hand-picked from a pool of existing designs. The criteria used back then were low enough flux density to safely operate as a step-up units, winding and oil temperature rises with a generous cushion to the then poorly known load/ambient temperature profiles, and with the operational features required by specific sites/owners. However, in today's highly competitive renewables marketplace, most OEM's have come to understand and manage the nuances of the application and generally optimize the transformer design and manufacture to provide a transformer that is not only more economical to supply as well as to operate, but also provides new features that reduce the risk for the users and to the system. Highly specialized design considerations, somewhat different from the tried-and-true distribution transformer workhorses, are nowadays set in motion to optimize and rationalize the use of materials and labor, and maximize the benefits of a given transformer design, from reducing losses, meeting impedance constraints, to terminal arrangement and cooling type and location, also including many others, like shielding, core grounding, harmonic content consideration, stray heating, switching, monitoring, tank pressure control, to name just a few. During today's session we will provide a glimpse into the more important design considerations that are made at the conceptual and design stages, that define the transformer which will be ultimately supplied to a customer. This way, those whose job it is to specify transformers may be able to obtain a transformer all the more suited for their requirements and their budgets.

Israel Barrientos, B.Sc.M.E. ('94), M.Sc.E.E. ('96), initiated his Engineering career in the local electrical utility, as Dispatch Center Operator. He then finished his Master's Degree right before joining Prolec GE Distribution Transformer Division, where he continued to work for more than 15 years, in several technical positions. He has also worked in the Large Motor and Generators Dept. in GE Australia, and at another fractional-kW transformer manufacturer. He is a seasoned engineer with experience in Design, Application, Operation and Diagnosis of all kinds of distribution transformers, large motors and generators. Israel is a Member of the IEEE and a Registered Professional Engineer in Mexico.



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Mobile Substations: Types and applications of mobile substations are presented. A mobile versus power transformer is discussed with emphasis on the temperature ratings and associated with it hybrid insulation system, short circuit and dielectric strength, oil preservation and cooling system design. The mobile transformer and substation testing is discussed. The essentials of specifications, protection and trailer components are also addressed. Examples of the mobile substations 10 MVA to 100 MVA with HV ranging from 25 kV to 230 kV class are also provided.

Marion Jaroszewski's expertise is in applications and design of transportable high temperature transformers and substations as well as core type power, generator step up, auxiliary and grounding transformers, autotransformers and voltage regulators. Mr. Jaroszewski graduated from Technical University of Lodz Poland with specialization in Transformers, Electric Motors and Generators. He worked as an Electrical Engineer in ELTA in Lodz Poland, Transformer Engineer in Alamo Transformers in Houston, TX and since 1985 in Delta Star, Inc. (formerly HK Porter). He was promoted to following positions: Senior Design Engineer in 1987, Manager of Engineering in 1995, Corporate Technical Officer in 2004 and General Manager of San Carlos facility the same year and to Vice President of the company in 2005.

Mr. Jaroszewski retired at the end of 2009 and currently works part time as a consultant and technical advisor for Delta Star, Inc. He is Life Member of IEEE and active participant in Transformer Committee working groups.

Generator Step-Up Transformers: Generator Step-up Transformers (GSU's) are a specific application that can present unique challenges to both the user and the manufacturer. The purpose of this presentation is to demonstrate how the unique parameters of this application can impact the design and construction of the transformer.

RP 8:00 AM – 12:00 PM

Slippery Slopes---Journey through Differential Protection---

Ed Khan, Director of Protection Testing

Doble Engineering Company

Ed Khan is with Doble Engineering Company. Mr. Khan has been with Doble for 10 years working in various capacities including Product Manager for protection tested related instruments. Currently, he is the Director of Protection R&D and Training at Doble. Prior to Doble, Mr. Khan has worked for GE, ABB, SEL, KEMA and others in various capacities. He has 36 years of experience in system studies, protection applications, relay design, power plant design, teaching and product management. He has a thorough knowledge about product development, protection, harmonic analysis, harmonic filter design, stability studies, real time digital simulations, generator protection and more. He has presented courses on behalf of GE and Doble in US, Southeast Asia, Middle East, Mexico, India and China. He also taught GE Protection course on few occasions.

Mr. Khan is a member of CIGRE and is currently a member of the CIGRE Working Group B5.56 (Optimization of Protection, Automation and Controls). He has written and presented papers and articles on protection and testing related topics.

9:45 AM – 10:00 AM

Break



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TP 10:00 AM – 10:30 AM

High-Temperature Transformers using Advanced Materials

Jerzy Kazmierczak, Commercial Operations Manager/LMPT
ABB Inc.

Jerzy Kazmierczak is Commercial Operations Manager for Medium and Large Power Transformers Plant, located in Saint Louis, MO. Responsible for Project Management, Proposal Managers and Quotation Engineers. He received his electrical engineering degree in 1998 at the Technical University of Lodz, Poland from the faculty of Electrical Machines and Transformers. He joined ABB the same year and started his career as an electrical designer for power transformers factory in Lodz. He later continued his work as Electrical Design Team Leader for that factory. In 2002 he moved to ABB Guelph in Canada and worked as electrical engineer designing power transformers until 2004 when he became Engineering Manager. In 2006 he relocated to Saint Louis, MO, where he took position of Electrical Design Engineering Manager in ABB Medium Power Transformer factory until July 2011. In August 2011 he became Engineering Manager for MLPT and TRES. September 2016 – Commercial Operations Manager. Working in the transformer business for almost 20 years he had been involved in new technology implementations in different factories, product and production process development. He is a part of the ABB global technical team contributing to R&D projects, technology and quality improvement initiatives. Since September 2016 he has been responsible for Commercial Operations at ABB St. Louis.

TP 10:30 AM – 11:00 AM

Transportation and Rigging

Rick Maloyed, Regional Sales Manager
Edwards Moving & Rigging

The transportation of large, heavy, and oversize transformers has always been fascinating and mysterious for those who have witnessed a large loaded trailer pass by, seen a crane lift at a port or just been amazed by the sheer size of the units. Some think it must be incredibly difficult while others say it is simple. This presentation is designed to provide Logistic Solutions and to better understand the challenges of moving transformers at all levels. Edwards Moving and Rigging moves over 300 large transformers annually. This presentation will provide real life examples and case studies to illustrate all modes of transport and rigging used in the transformer industry as well as provide logistical considerations and applications for moves, whether an internal movement of a spare within a utility or receiving a new transformer from factory to pad.

Rick Maloyed has overseen multiple multi-modal transportation projects over the last seven years at Edwards Moving & Rigging, Inc. as its Northeast Region Sales / Project Manager. His range of experience includes the successful oversight and design of over-weight and over-dimensional transport solutions for HRSBs, turbines, vessels, transformers and other super-load projects. In addition, he has overseen the planning and execution of various specialized rigging projects at power plants, substations, nuclear sites, refineries, and other industrial markets throughout the northeast. The majority of these projects have involved over the road transport, necessitating significant time investment in permit procurement, overhead obstruction issues, and bridge studies. Mr. Maloyed holds a BA degree and 30-Hour OSHA certification.

TP 11:00 AM – 12:00 PM

Transformer Bushing Fundamentals



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David Geibel, Technical Director
Durand Stacy, Engineering Supervisor
ABB Inc.

This bushing fundamentals session will cover bushing theory, design, function, terminology, standards, and different insulation technologies. Advantages, disadvantages, and differences in the types of oil-impregnated paper (OIP) bushings and dry & composite-type bushings available on the market today will be discussed. Attendees will have a clear understanding of installation, maintenance, and testing procedures, and the challenges that may be encountered when working with OIP and dry & composite-type bushings. A thorough understanding of the details needed when planning a bushing replacement project will be presented.

David Geibel started out at General Electric Co. in Pittsfield MA over four decades ago and became a transformer components engineer. GE sold him to Westinghouse and Westinghouse sold him to ABB. Mr. Geibel has been the Engineering Manager for the ABB Alamo transformer components plant for about the past decade and have recently transitioned over to Technical Director. He graduated Magna Cum Laude from the University of Pittsburgh with a BSEE and holds several transformer components patents.

Durand Stacy graduated Magna Cum Laude from Bluefield State College with a Bachelor of Science degree in Electrical Engineering and holds several transformer components related US Patents. Stacy was hired by ABB in 1997 at the ABB facility in Bland VA where his high voltage apparatus career began with the design of Air Disconnect Switchgear. In 2000, Mr. Stacy relocated to the ABB facility in Alamo, TN. At various times during his career in Alamo, he held engineering responsibility for power bushings, de-energized tap changers (DeTC), on load tap changers (OLTC), and components for pad mount transformers. In 2015, Durand accepted his current role as Commercial Order Engineering Supervisor for all products manufactured at the ABB Alamo facility and also retains his technical leadership role as Consulting Engineer.

12:00 PM – 1:30 PM

Industry Expo & Reception

ABB and Delta Star will have heavy equipment on display during Industry Expo.

TP 1:30 PM – 2:15 PM

Intelligent Transformer Condition Monitoring

Tony McGrail, Solutions Director, Asset Management & Monitoring
Technology

Doble Engineering Company

Stephan Brauer, Chief Technology Officer, Equipment
Morgan Schaffer

In this presentation we will look at aspects of transformer condition monitoring - from the need to set goals and defining relevant monitoring parameters through to communicating of data/information and the need to have a predefined and agreed action plan. Intelligent condition monitoring can yield great benefits and we will discuss and present ways and means to achieve those benefits. Dissolved gas analysis, bushing, partial discharge and other condition monitoring solutions will be discussed.



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Tony McGrail is Doble Engineering Company's Solutions Director for Asset Management & Monitoring Technology, providing condition, criticality and risk analysis for utility companies. Previously Dr. McGrail has spent over 10 years with National Grid in the UK and the US; he has been both a substation equipment specialist, with a focus on power transformers, circuit breakers and integrated condition monitoring, and has also taken on the role of substation asset manager and distribution asset manager, identifying risks and opportunities for investment in an ageing infrastructure. Dr. McGrail is a Fellow of the IET, Chairman of the IET Council, a member of the IEEE, ASTM, CIGRE and the IAM, is currently on the executive committee of the Doble Client Committee on Asset and Maintenance Management, and a contributor to SFRA and other standards. His initial degree was in Physics, supplemented by an MS and a PhD in EE and an MBA. Dr. McGrail has a commitment to lifelong learning and is an Adjunct Professor at Worcester Polytechnic Institute, MA, leading courses in power systems analysis and distribution fundamentals.

Stephan Brauer has managed product development and technology strategy at Morgan Schaffer since 2005. Dr. Brauer previously led technology development at small, medium and large organizations in both the private and public sector, specializing in precision measurement instruments. He holds a degree in engineering physics from Queen's University and a Ph.D. in experimental physics from McGill. Dr. Brauer is the author of numerous publications and is a member of IEEE, APS, ASTM, and CIGRÉ.

RP 1:30 PM – 2:15 PM

Sudden Pressure Relays—Concept, Construction, Application & Testing

Emilio Morales, Technical Application Specialist
Qualitrol

Learn the theory behind the deployment of the sudden pressure relays in preventing further catastrophic events within a transformer in the case of a rapid pressure rise. Realize the methodology behind placement and application of both mechanical and electronic models, including two out three logic and adjustable sensitivity. View construction methods and understand the distinct advantages between mechanical and electronic models. Proper installation tips will be discussed to ensure units are operating in the manner in which they are intended on both new and retrofit installations. Principles behind field testing will be demonstrated as well as the importance of maintaining unit health in the field to avoid potential false trips.

Emilio Morales is a Technical Application Specialist in Transformer applications at Qualitrol Company LLC. His main focus is to support solutions in comprehensive monitoring for Transformer applications. Emilio attended Nuevo Leon State University in Mexico, receiving his Bachelor degree in Electro Mechanical Engineering in 1980. He has over 30 years of experience in power transformer design which includes transformers up to 500 MVA and 500 kV, furnace and rectifier transformers and reactors. He is member of the IEEE/PES Transformer Committee, IEC and CIGRE. Emilio joined Qualitrol in June 2012 and previously worked with GE-Prolec, Ohio Transformer, Sunbelt Transformer and Efacec.

TP 2:15 PM – 3:15 PM

Transformer Cooling Fundamentals

Craig Stiegemeier, Expert Services Product Manager
ABB Inc.

Kevin Riley, Supplier & Product Development Manager



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Trantech Radiator Products

With temperature control being crucial in newer transformers, heat dissipation becomes very important. However, cooling system performance, with or without moving mechanical equipment, deteriorates with age. Even systems without oil-pumps or fans can fail due to weathering, rusting and fouling. How do we evaluate the health of the cooling system? Technology has improved with time, so what optimized solutions are available?

Craig Stiegemeier is the Director of Technology and Business Development for ABB's North American Transformer Remanufacturing and Engineering Services (TRES) organization. He is responsible for developing effective processes supporting condition evaluation, assessment tools and life extension solutions for utility and industrial users of power transformers. Mr. Stiegemeier began his career 36 years ago as a development and design engineer for large shell-form transformers for Westinghouse in Muncie, Indiana. He also has project management experience for the US Navy as well as technical and commercial management for ABB's transformer components business. He led the ABB TrafoStar winding production improvement processes and was commercial operations manager for the St. Louis power transformer operations before moving into transformer services in 2004.

Kevin Riley is a Mechanical Engineer and certified Six Sigma Black Belt. He has been with Trantech Radiator Products for seven years and is currently the Quality and Product Development Manager. Mr. Riley has worked in the heat exchanger industry for over 10 years holding positions at Young Touchstone and Trantech within senior engineering and operations for products as diverse as Cuprobrazed, Fin and Tube and Plate Radiator technologies. He has also worked with Electric Utility and Generation customers for over 12 years in the Fleet, Genset and T&D sectors. He currently works on cooling systems development and components with OEM and utility customers for new and replacement applications covering all types of transformers and equipment. Before beginning his career in the private sector with Caterpillar, Mr. Riley served as an officer in the United States Navy.

RP 2:15 PM – 3:15 PM

Buchholz Relays – Concept, Construction, Application & Testing

Tim Rinks, Area Sales Manager

Reinhausen

This presentation will talk about the the concept, construction, application and testing of Buchholz relays. These relays, which are applied on liquid filled transformers and reactors with oil conservators, act as a central protection system. Installed in the pipeline between tank and oil conservator, it reacts to faults which occur inside the transformer. Damages which are not visible can be detected early by the Buchholz relay. Gases moving in the direction of the oil conservator or shock waves created by the rapid gas development trigger the signaling system of the Buchholz relay. The Buchholz relay also takes over the function of an oil level indicator when there is not enough oil in the conservator or when there is an oil leak.

3:15 PM – 3:30 PM

Break

TP 3:30 PM – 5:00 PM

Load Tap Changer Fundamentals

David Geibel, Engineering Manager

ABB Inc.



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Bernhard Kurth, General Manager
Reinhausen Manufacturing, Inc.

Energized Load Tap Changers (LTCs), De-Energized (DETC), Transmission Class, Distribution Class, Resistive, Reactive, and so very much more. This is by far one of the most impressive presentations of the week, and it is jam-packed with information about history, usage, various designs, operations, maintenance, gas analysis, repairs, failures and components. Representatives of ABB and Reinhausen will be on hand to make presentations and then open the floor for discussion, and most importantly, to field your questions. This extremely practical presentation will allow the attendees to ask about all types of subjects related to the everyday operations, loading, and maintenance of transformer tap changers.

David Geibel started out at General Electric Co. in Pittsfield MA over four decades ago and became a transformer components engineer. GE sold him to Westinghouse and Westinghouse sold him to ABB. Mr. Geibel has been the Engineering Manager for the ABB Alamo transformer components plant for about the past decade and have recently transitioned over to Technical Director. He graduated Magna Cum Laude from the University of Pittsburgh with a BSEE and holds several transformer components patents.

Bernhard Kurth was born in Quito, Ecuador on June 29, 1960. He received a M.S. degree in Electrical Engineering from Rhineland Westphalia Technical University at Aachen, Germany in 1987. Mr. Kurth has been around On-Load and Off-Circuit Tap Changers for his entire career. He has been President of Reinhausen Manufacturing in Humboldt, TN since its foundation in 1991. Before joining Reinhausen Manufacturing, Bernhard worked as Area Sales Manager at Maschinenfabrik Reinhausen GmbH in Regensburg, Germany, being then transferred as President of Reinhausen Canada Ltd. to Toronto, Canada in 1990.

RP 3:30 PM – 4:15 PM

Integration of Protection Data & Transformer Gas Analysis for Full Asset Monitoring

Terrence Smith, Commercial Applications Director
GE Grid Automation

Transformer differential is one of the most often mis-operated protection systems within the power system. When the differential operates, it is often difficult to determine cause because a fault may be buried deep within the transformer. Dissolved Gas Analysis (DGA) can help the trouble-shooter make statements about thermal faults and arcs and faults and help to identify the presence of a legitimate transformer fault. DGA can also help the transformer asset management team make long term statements about the health of the transformer over-time. An on-line DGA system can be added to the transformed to give reliable continuous data about the health of the transformer. Additionally, the on-line DGA can help to trouble-shoot after a transformer fault by giving dissolved gas analysis of the transformer oil. This paper examines a novel technique which uses the electrical fault data from a transformer and the DGA data and incorporates them into a single report to facilitate faster decision making after a transformer fault.

Terrence Smith is the Commercial Application Director for the GE Grid Automation North American Commercial team. In this role he leads the team of technical application engineers supporting the Protection and Control,



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Substation Automation, and Monitoring and Diagnostics portfolio. He joined GE in 2008 supporting the Grid Automation Protection and Control Portfolio. Prior to joining GE, Terrence has been with the Tennessee Valley Authority as a Principal Engineer and MESA Associates as Program Manager. He received his Bachelor of Science in Engineering majoring in Electrical Engineering from the University of Tennessee at Chattanooga in 1993 and is a professional Engineer registered in the state of Tennessee. He has authored and presented several white papers at IEEE conferences and white paper conferences in the United States

RP 4:15 PM – 5:00 PM

Digital Transformers – the Building Block of Smart Grid

Dr. Alex Q. Huang, Ph.D.

Dula D. Cockrell Centennial Chair in Engineering Department of Electrical and Computer Engineering University of Texas at Austin

Through the development and commercialization of technology over the last fifty years, power electronics technology for low voltage systems (<480 V) can be easily achieved by using silicon IGBT technology. Newer semiconductor device based on SiC that can handle much higher voltage and higher switching frequency were only becoming available in the last decade. SiC power switches have been demonstrated with a blocking voltage from 10 kV to 24 kV. In addition to these gigantic improvements in voltage ratings, the switching speed of these devices is also significantly faster than Si IGBT. Utilizing the advanced SiC power electronic technology, modular and software configurable power electronics solution can now be developed to transform the legacy power grid to a smart and resilient grid that is not only efficient but also capable of integrating new energy resources and new types of loads (e.g. data centers and electric vehicles), as well as to provide many smart functions to the grid. This talk will discuss the concept of the solid state transformer (SST) or digital transformer (DT) with a focus on its operation, smart features and protection strategy.

Alex Q. Huang (S91-M94-SM96-F05) was born in Zunyi, Guizhou, China. He received his B.Sc. degree from Zhejiang University, China in 1983 and his M.Sc. degree from Chengdu Institute of Radio Engineering, China in 1986, both in electrical engineering. He received his Ph.D. from Cambridge University, UK in 1992. From 1992 to 1994, he was a research fellow at Magdalene College, Cambridge. From 1994 to 2004, he was a professor at the Bradley Department of Electrical and Computer Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. From 2004 to 2017, he was the Progress Energy Distinguished Professor of Electrical and Computer Engineering at NC State University where he established and led the NSF FREEDM Systems Center. Since 2017, he has become the Dula D. Cockrell Centennial Chair in Engineering at University of Texas at Austin. Since 1983, he has been involved in the development of modern power semiconductor devices and power integrated circuits. He fabricated the first IGBT power device in China in 1985. He is the inventor and key developer of the emitter turn-off (ETO) thyristor. He developed the concept of Energy Internet and the smart transformer based Energy Router technology. His current research interests are power electronics, power management microsystems and power semiconductor devices. He has mentored and graduated more than 80 Ph.D. and master students, and has published more than 500 papers in international conferences and journals. He has also been granted more than twenty U.S. patents. He is the recipient of the NSF CAREER award, the prestigious R & D 100 Award and the MIT Technology Review's 2011 Technology of the Year award.

5:00 PM – 5:30 PM

Ask the Experts Panel



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5:30 PM – 7:00 PM

Industry Expo & Reception

ABB and Delta Star will have heavy equipment on display during Industry Expo.

Wednesday, February 21, 2018

6:30 AM – 6:00 PM

Registration & Information Desk Open

6:30 AM – 8:00 AM

Attendee Breakfast

TP &

TM 8:00 AM – 9:30 AM

Transformer Assembly, Oil Processing & Commissioning

Troy Kabrich, Vice President & General Manager – Services Division
SPX Transformer Solutions, Inc.

This presentation will highlight recommendations for the proper receipt, inspection, field assembly, oil processing, and acceptance testing of large liquid immersed power transformers. Transformer field installation processes and standards will be reviewed to include impact recorders, equipment requirements, assembly operations, field dry out techniques, determination of insulation moisture concentration, provisions for cold ambient temperature processing, vacuum filling processes, and acceptance testing.

***Troy Kabrich** is currently the Vice President & General Manager for the Goldsboro, NC Manufacturing Plant and the Service and Components Division of SPX Transformer Solutions, Inc. During his twenty-five years of industry experience, Mr. Kabrich has held positions as a Plant Manager, Director of Field Services, Repair Operations Manager, Field Service Engineer, and Sales Engineer. He has published articles for T&D World and Utility Automation and Engineering magazines, was author of Installation and Maintenance Chapter of Third Revision of the Electric Power Transformer Engineering Handbook, and is a frequent contributor to industry training programs. Troy has a Bachelor of Science degree in electrical engineering from Rose-Hulman Institute of Technology.*

TP-A 8:00 AM – 9:30 AM

Transformer Design Review and Factory Inspections

Bill Griesacker, Principal Engineer

Doble Engineering Company

An effective procurement system utilizes the preapproval process to identify suitable power transformer vendors and a design review to establish an agreed upon design and procurement process. This preapproval approval process should include factory qualification audits which are essential to confirm a manufacturer's ability to meet a purchaser's requirements and expectations. The design review is performed to establish an agreed upon design and to facilitate the procurement process. That the supplier is capable of meeting the purchaser's procurement specifications is confirmed during this process and the procurement process is



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expedited by bringing the purchaser and supplier together on the technical details of the purchased transformer.

Bill Griesacker is a member of Doble Engineering Company as a transformer engineer working on projects that include factory inspections, condition assessment, design reviews, failure analysis and general consulting. He previously worked for Pennsylvania Transformer Technology Inc., where he held various positions including Engineering Manager. His work included high voltage insulation design, transient voltage modeling of power transformer windings and various LTC and DETC switch development projects. Prior to this, he was employed by the Westinghouse Electric Company, working on synchronous generator projects as a member of the Generator Engineering Department. Mr. Griesacker started his career with Cooper Power Systems in large power transformers and later worked in the Kyle Switchgear, Vacuum Interrupter Department. He has earned a MS in electric power engineering from the Rensselaer Polytechnic Institute and a BS in electrical engineering from Gannon University. Mr. Griesacker is an active member of the IEEE, PES Transformers Committee where he holds positions in several working groups and subcommittees.

RP 8:00 AM – 9:00 AM

Differential Protection including Sensitive Negative Sequence Element for Turn to Turn Faults

Karl Zimmerman, Principal Engineer

Schweitzer Engineering Laboratories

In this session, we will discuss traditional transformer differential protection, and some of the challenges and solutions associated with protection security and dependability. One challenge is that during heavy load conditions, the resulting increase in restraint current renders traditional phase differential element less sensitive, particularly from detecting transformer winding interturn faults. Since negative-sequence currents are unaffected by load for balanced conditions, a negative-sequence differential element can provide more sensitive protection.

RP 9:00 AM – 10:00 AM

Software Tools to Verify Transformer Relay Performance for Commissioning & Field Events

Karl Zimmerman, Principal Engineer

Schweitzer Engineering Laboratories

Transformer differential protection can be successfully applied and commissioned if we follow some simple rules using nameplate data, ct connections, phase-to-bushing connections, and polarity. Still, mistakes can occur. Sound testing and commissioning using event reports and software tools to view and validate measured currents and voltages can greatly improve reliability and reduce errors. In this session, we demonstrate some practical commissioning, testing and troubleshooting principals that lead to successful transformer differential deployment and performance.

TP &

TM 9:30 AM – 10:15 AM

Insulating Fluid Basics & How to Take a Proper Oil Sample



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David Koehler, Technical Manager
Doble Insulating Materials Laboratories

This presentation will provide information on insulating fluids, focusing on various characteristics and the most common analytical tests performed on insulating fluids to assess the condition of the insulating fluid and health of the transformer. Important aspects of the sampling process for insulating fluids will be covered to help ensure that a representative sample of the bulk insulating fluid is obtained.

David Koehler received his Bachelor's Degree in Chemistry from Indiana University and obtained his M.B.A. He is the New Business Development and Technical Manager for the Doble Engineering Company Insulating Materials Laboratories. He has 19 years of experience in the testing of insulating liquids and management of analytical laboratories. Mr. Koehler has provided numerous technical presentations and published technical articles within the power industry. He is a member of the ASTM D-27 Technical Committee on Electrical Insulating Liquids and Gases. In 2011, he was an Executive Committee Member of the Indiana American Chemical Society. In 2016, David was elected by the IEEE Region 4 voting members to the position of Region 4 Director-Elect. In 2017-2018 David serves as the Region 4 Director-Elect, chairing the IEEE Region 4 Strategic Planning Committee. In 2019-2020 Mr. Koehler will serve as the IEEE Region 4 Director, while also serving on the Board of Directors for IEEE.

TP-A 9:30 AM – 10:15 AM **LTC Maintenance Requirements and Steps for In-Tank LTC**
Bernhard Kurth, General Manager
Reinhausen Manufacturing Inc.

Bernhard Kurth was born in Quito, Ecuador on June 29, 1960. He received a M.S. degree in Electrical Engineering from Rhineland Westphalia Technical University at Aachen, Germany in 1987 and has been around On-Load and Off-Circuit Tap Changers for his entire career. He has been President of Reinhausen Manufacturing in Humboldt, TN since its foundation in 1991. Before joining Reinhausen Manufacturing, Mr. Kurth worked as Area Sales Manager at Maschinenfabrik Reinhausen GmbH in Regensburg, Germany, being then transferred as President of Reinhausen Canada Ltd. to Toronto, Canada in 1990.

10:00 AM – 10:30 AM **Break**

ALL 10:30 AM – 12:00 PM **Transformer Field Testing**
Robert Brusetti, Director, Client Service Engineering
Doble Engineering Company

Financial implications and complex of the asset are the primary reasons power transformers are viewed as the most critical component in the electric power system. Field-testing provides the engineer with a group of tools to assess the condition of the transformer and to identify problems and the level of criticality. Each test provides data to support decisions about transformer. The early detection of problems can minimize the repairs involved and mitigate catastrophic failures. The scope of this presentation is to consolidate all the current techniques for field testing transformers and identify each test's true capability.



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Robert Brusetti received his BS in Electrical Engineer degree from the University of Vermont in 1984 and a MBA from Boston College in 1988. He has been employed at Doble Engineering Company for twenty years and currently serves as Director of Client Service Engineering. Prior to his present responsibility he has held positions as Product Manager and Field Engineer. Mr. Brusetti is a licensed Professional Engineer in the state of Massachusetts.

12:00 PM – 1:00 PM Lunch

TP &

TM 1:00 PM – 1:45 PM

Transformer Oil Processing & Field Vacuum Dry-out

Greg Steeves, Chief Technical Officer

Baron USA, LLC

Transformer life depends mainly on the condition of the liquid & solid insulation. The liquid insulation can be maintained and restored with purification & reclamation. The solid insulation however is difficult to maintain directly. Various technologies and techniques are available to maintain the insulation (both directly & indirectly). Appropriate selection and application of transformer dry-out technologies and techniques can extend transformer life, reduce downtime and save money. These technologies and their field applications will be discussed during this presentation.

Greg Steeves is the Chief Technical Officer and principle engineer of Baron USA, LLC. Baron is the premier provider of transformer dry-out and dielectric fluid processing systems for OEM's, utilities and field service organizations worldwide. Greg joined Baron USA as Engineering Manager in 1987. He is currently responsible for managing the daily operations and overseeing the application, engineering design and manufacturing of oil purification equipment, vacuum chambers, vapor phase processing and transformer dry-out equipment. He earned his degree in Mechanical Engineering from Tennessee Technological University and is licensed in the state of Tennessee.

TP-A 1:00 PM – 1:45 PM

EMI Diagnostic Testing:

Generator, Iso-Phase & Transformer In-Service Testing

James Timperley, Senior Principal Engineer

Doble Engineering Company

Since 1980 electromagnetic interference (EMI) Diagnostics has provided information on the electrical and mechanical condition of several thousand mission critical assets in power plants, heavy industry, petrochemical and marine locations. This on-line technique has been applied to many sizes and designs of generators, motors, transformers, switchgear, power cables and bus. This session provides case studies of electrical and mechanical deterioration identified with EMI Diagnostics. Several methods for data analysis are offered.

James E. Timperley is currently a Sr. Principal Engineer with Doble Engineering. He has 45 years' experience in the power industry with an emphasis on diagnostic testing, large electrical rotating machinery and isolated phase bus. Jim has authored more than 80 technical papers in the areas of applied research, advanced insulation



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systems, diagnostic testing, failure investigation, inspecting, maintaining and specifying rotating machinery for IEEE, Doble, ASME, CIGRE, EPRI, DEIS, PCIC and the American Power Conference. His work has involved root cause analysis of equipment failures, insulation deterioration mechanisms and developing repair procedures for use at petrochemical and industrial sites as well as in fossil, nuclear and hydroelectric power plants.

RP 1:00 PM – 2:30 PM

Demonstration of Testing GE T60 Transformer Relay

Ed Khan, Director of Protection Testing

Doble Engineering

Ed Khan is with Doble Engineering Company. Mr. Khan has been with Doble for 10 years working in various capacities including Product Manager for protection tested related instruments. Currently, he is the Director of Protection R&D and Training at Doble. Prior to Doble, Mr. Khan has worked for GE, ABB, SEL, KEMA and others in various capacities. He has 36 years of experience in system studies, protection applications, relay design, power plant design, teaching and product management. He has a thorough knowledge about product development, protection, harmonic analysis, harmonic filter design, stability studies, real time digital simulations, generator protection and more. He has presented courses on behalf of GE and Doble in US, Southeast Asia, Middle East, Mexico, India and China. He also taught GE Protection course on few occasions. Mr. Khan is a member of CIGRE and is currently a member of the CIGRE Working Group B5.56 (Optimization of Protection, Automation and

TP &

TM 1:45 PM – 2:30 PM

Industry Strategies for Improved US Electric Grid Resiliency

Hardened Cyber Asset Security: Gowri Rajappan, Doble Engineering Company

Transformer Physical Security Hardening Solutions: Craig Stiegemeier, ABB

Enabling Grid Resilience with Mobile Transformers: Jim McIver, Siemens

TP-A 1:45 PM – 2:30 PM

System Critical Non-Segregated Phase Bus Inspection & Maintenance Best Practices

Mohsen Tarassoly, Director of Sales & Business Development

Electrical Builders Inc. (EBI)

This presentation will review best practices for analysis, inspection, cleaning and maintenance of the bus duct systems of the power generation facility. Many plant operations and maintenance managers ignore the bus duct system, forgetting it is a system critical component in the power plant that does not have redundancy AND is connected to expensive plant assets on both ends. The presentation will review numerous case studies from more than forty years of field.

Mohsen Tarassoly is the Director of Sales & Business Development at Electrical Builders, Inc. (EBI). Mr. Tarassoly is an electrical engineer, earning his EE degree from Penn State. He has over 25 years of experience in both the domestic and international power industry working with most major utilities, EPC's, and engineering entities. His experience includes executive management roles with some of the largest OEM manufacturers of Isolated Phase Bus, Non-Segregated, and Segregated Phase Bus systems, including Powell/Delta Unibus and Technibus/ABB.



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TM 2:30 PM – 3:00 PM

NERC TPL-007 Compliance – Geomagnetic Disturbance Risk Mitigation

Dom Corsi, Senior Transformer Consulting Engineer

Doble Engineering Company

Severe geomagnetic disturbances (GMDs) caused by solar storms in upper atmospheric layers can induce currents in long conductors on the Earth's surface, such as power lines, which can overload the electric grid system triggering voltage collapse, or worse, damage expensive extra-high voltage power transformers. To adhere to the new NERC standard TPL-007-1, applicable entities must assess the potential impact of a "1-in-100-year" benchmark GMD event on the bulk power system potentially including a transformer thermal impact assessment to ensure that all high-side, wye grounded transformers above 200kV can withstand the thermal transient effects associated with benchmark GMD event.

This session will address how geomagnetic disturbances can impact transformers, the new NERC standards to address geomagnetic disturbance events, transformer thermal impact assessment requirements and assessment approaches for service aged transformers with limited original design data.

Dom Corsi has 27 years of experience in the manufacturing and electrical design of large power transformers. This experience includes both core and shell form designs. Mr. Corsi joined Doble in 2004 as a Transformer Consulting Engineer for Doble Global Power Services. In the last 12 years, he has concentrated on electrical power apparatus testing, condition assessment, and forensics. Additionally he has designed transformers up to 400 kV and 570 MVA and reviewed or supervised transformer designs to 525 kV and 1100 MVA. His main interests are in the fields of power transformer design, and power transformer applications. A frequent presenter, Dom Corsi trains participants on many transformer related topics including Transformer Repair, Remanufacturing and Replacement, Transformer Design Review, Transformer Factory Inspections.

3:00 PM – 3:15 PM

Break

TP &

TM 3:15 PM – 5:00 PM

Transformer Life Extension & Maintenance Solutions

Transformer Oil Reclamation while Energized: Siemens

Stray Gassing Analysis & Mitigation: Jim Algood, Duke

Transformer Leak Repair: Steve Wickman, TDS-Transmission & Distribution Services

Load Tap Changer Life-Extension Case Study: Ken Carpenter, GE

Phase Shifter Transformers Load Tap Changer Upgrades: John Lott, PSEG

Stray Gassing Analysis & Mitigation: McGuire Nuclear Station has had a history of hot metal gas generation (Methane/Ethane) in its Large Oil Filled Transformers for many years. Since all transformers were exhibiting the same general gas pattern, including a non-energized spare, and no CO or CO₂ was involved, the general feeling was that the Ethane/Methane generation was more of a Chemical issue and not real hot metal condition in the



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transformer. This presentation is intended to share the lessons learned from various oil tests, processing, and the effect of O2 Inhibitor on the gas generation rates.

***Jim Algood** is Principal Engineer for Duke Energy's McGuire Nuclear Station. Mr. Algood joined Duke in 1977 and was responsible for oversight of many of the electrical power component installations at Catawba Nuclear Station, including the main transformers. Since 2007 he has been primarily responsible for the Main Power Systems at McGuire and written purchase specifications for replacement GSUs, performed Design Reviews, made factory inspections, and witnessed FAT testing of these transformers.*

Transformer Leak Repair: Tightly scheduled transmission system outages make it difficult to take extended outages for transformer maintenance and repair. Emergent repairs for issues such as oil leaks usually cannot wait 6 months from discovery of the oil leak to making the repair. The most common leak repair solution is to remove every radiator and bushing and regasket every flange to prevent all future leaks. This work can take weeks if the transformer is a large generating station step up transformer or large HV or EHV transformer in a transmission-type substation. This presentation will describe an alternative oil leak repair technique by means of drilling and injecting sealant compound into the leaking transformer gasket groove on the leaking flange. This technique will work on radiator flanges, pump flanges, piping flanges, as well as injecting into flapper valve stems. These repair techniques require an initial inspection, usually performed with the transformer in service. Many repairs on the lower end of transformer radiators, and pumps and piping can be performed with the transformer in service. Leaks on the upper end of radiators and bushing flanges usually require an outage for safe work clearances, but can be performed in one or two days.

***Steve Wickman**, PE has had a 37-year career as a Power Engineer with Commonwealth Edison in the greater Chicago, IL area. Mr. Wickman holds a BSEE from Iowa State University and MBA from Keller Graduate School of Management [DeVry University]. His 40+ year engineering career has spanned work experiences in substation equipment testing and commissioning, design engineering, substation construction and operations management, as well as project management, work scheduling and work controls areas. He currently works as an independent consultant in the electric utility industry.*

Load Tap Changer Life-Extension Case Study: GE Service Factory Transformer Repair Summary- PowerPoint describing a summary of the repair process for a typical medium to large power transformer. Topics include: - Failure modes -Incoming inspection, testing, untanking -Design, redesign, materials -Disassembly, rewind, re-assembly -Tanking, dry-out -Testing.

***Kenneth R. Carpenter**, Senior Transformer Designer GE Energy Connections Ken develops designs for remanufactured transformers ranging up to 300MVA and 345kV and provide engineering solutions to upgrade the transformer to modern design standards as well as increase efficiency or power handling as required. He began his career with GE in 1989 as a transformer design engineer in Rome, GA, after four years of prior design experience at outside firms. He holds a BSME from NCSU.*

Phase Shifter Transformers Load Tap Changer Upgrades: The presentation covers the work PSEG Long Island completed on one of Long Island Power Authority's Phase Shifting Transformers located at the Lake Success Substation in 2017. The scope of the work replaced both GE LRT-400 LTC's on the Exciter unit with new



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Reinhausen Manufacturing RM-II LTC 's. In addition to the LTC replacements, PSEG Long Island also complete a life extension on the unit.

John Lott has been employed at PSEG long Island since 1988, and currently works as a Technical Manager in the Substation Maintenance Department. Mr. Lott received his Bachelor of Science Degree in Electrical Engineering Technology from Old Dominion University in Virginia and a Masters of Science Degree in Technological Systems Management from Stonybrook University in New York. He is a Military Veteran who served in the Navy's United States Submarine Service. He holds a New York State Professional Engineering License.

RP 3:15 PM – 4:00 PM

Testing and Troubleshooting Tools used with Transformer Protection Relays

Drew Welton, Director of Sales

Beckwith Electric

Various types of digital relays designed for transformer protection offer software that can assist test engineers and technicians during the testing process. Since mechanical calibration is no longer a concern, our testing focus is associated with the proper setting and configuration of the protective elements. In this session, we will:

1. Review of the protective elements associated transformer protection
2. Assure proper validation of the transformer configuration
3. Use the relay software to visualize and validate proper CT secondary wiring
4. Test the 87 elements
5. Test the harmonic restraint
6. Discuss the importance of, and test over excitation protection with the V/Hz element

We will use a Beckwith relay model M-3311A and related software to assist throughout the testing process, which can also be associated with other types of transformer protective relays.

Drew Welton, Director of Sales for Beckwith Electric Company, provides strategic sales leadership and further develops and executes Beckwith's market development and business plans. Mr. Welton was previously the North American Regional Manager for OMICRON, starting with the company in 1997. Prior to his career with OMICRON, he was a Regional Sales Manager with Beckwith Electric. He also served as National Sales Director for Substation Automation with AREVA T&D.

Mr. Welton is the author of numerous articles on substation maintenance testing, and has conducted training sessions for substation technicians and engineers at utilities and universities across North America. He has a bachelor's degree in Business Administration from Fort Lewis College, Durango, Colorado. He is a 20 year Senior Member of IEEE-PES, has been a contributor on a number of PSRC working groups, and presented at many industry conferences specific to power system protection and control.

RP 4:00 PM – 5:00 PM

Concepts & Enhancements of Transformer Protection

Roy Moxley

Siemens



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Fault energy is the key component to causing transformer damage from through fault current, and increasing damage from internal transformer faults. This discussion will focus on avoiding transformer damage by implementing faster fault clearing on close in faults and reducing transformer damage by faster tripping on internal faults. Relay operating principles, security, and testing limitations and practices will be presented.

Roy Moxley has worked in relaying and T&D application engineering for more than 36 years. He joined Siemens Smart Grid as Principle Power Systems Protection Consultant in 2012, following 23 years at GE and 13 years at SEL. Mr. Moxley holds a BSEE from the University of Colorado at Boulder. He is a member of IEEE, a PE in Pennsylvania and a seasoned presenter with more than 20 papers on protective relay to his credit.

5:00 PM – 5:30 PM

Ask the Experts Panel

6:00 PM – 9:00 PM

Social Event at Granite City Food & Brewery

Seminar attendees and their guests are invited to nearby Granite City Food & Brewery for dinner, drinks and conversation. Hosted by Doble Engineering Company.

Thursday, February 22, 2018

6:30 AM – 5:30 PM

Registration & Information Desk Open

6:30 AM – 8:00 AM

Attendee Breakfast

TP &

TM 8:00 AM – 8:45 AM

Factory Repair

Ken Carpenter, Senior Design Engineer

GE Energy Connections

Learn the repair process for a typical medium to large power transformer including failure modes -incoming inspection, testing, untanking, design, redesign, materials, disassembly, rewind, re-assembly, tanking, dry-out and testing.

Kenneth Carpenter, Senior Transformer Designer GE Energy Connections Ken develops designs for remanufactured transformers ranging up to 300MVA and 345kV and provide engineering solutions to upgrade the transformer to modern design standards as well as increase efficiency or power handling as required. He began his career with GE in 1989 as a transformer design engineer in Rome, GA, after four years of prior design experience at outside firms. He holds a BSME from NCSU.

TP-A 8:00 AM – 8:45 AM

Advanced Insulating Fluid Materials

Edward Casserly, Director Refinery Research & Development

Ergon



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Jinesh Malde, Applications Engineer
M&I Materials Inc.

Ed Casserly received his B.A. in Chemistry from the University of St. Thomas and his Ph.D. in Organic Chemistry from Rice University, Houston, Texas. Ed began his career as a research chemist with Pennzoil and Penreco, a specialty hydrocarbon producer. He has been involved with R&D and technical support for specialty petroleum products for over 30 years. He is a co-inventor on 7 US patents on synthetic hydrocarbon fluids and has published many technical papers. Ed is currently Director of Refinery Research and Development for Ergon Refining, Jackson, Mississippi. He is a member of IEEE, Cigre, ASTM D27

Jinesh Malde received B.Ss in Electrical Engineering from Lawrence Technological University, Southfield MI in 2007. For 3 years he worked as transformer design engineer at Marcie Electric Inc. followed by 6 years at Weidmann Electrical Technology Inc. as distribution transformer engineer. In 2016 Mr. Malde joined M&I Materials Inc. as applications engineer supporting customers with the application of natural and synthetic esters in transformers.

RP 8:00 AM – 10:00 AM

All Elements of Transformer Protection

Ed Khan, Director of Protection Testing

Doble Engineering Company

Ed Khan is with Doble Engineering Company. Mr. Khan has been with Doble for 10 years working in various capacities including Product Manager for protection tested related instruments. Currently, he is the Director of Protection R&D and Training at Doble. Prior to Doble, Mr. Khan has worked for GE, ABB, SEL, KEMA and others in various capacities. He has 36 years of experience in system studies, protection applications, relay design, power plant design, teaching and product management. He has a thorough knowledge about product development, protection, harmonic analysis, harmonic filter design, stability studies, real time digital simulations, generator protection and more. He has presented courses on behalf of GE and Doble in US, Southeast Asia, Middle East, Mexico, India and China. He also taught GE Protection course on few occasions. Mr. Khan is a member of CIGRE and is currently a member of the CIGRE Working Group B5.56 (Optimization of Protection, Automation and Controls). He has written and presented papers and articles on protection and testing related topics.

TP &

TM 8:45 AM – 10:00 AM

Transformer Asset Health Indexing & Fleet Management

Paul Griffin, Vice President Global Professional Services

Doble Engineering Company

Carl Kapes, Manager – Transmission & Substation Reliability

Pepeco Holdings

Robert Allison

Dominion Energy

In today's modern utility, capital investments in transmission and distribution assets can be on the order of billions of dollars. With all that spending, there is enormous pressure to ensure that we are making the right



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decisions with regard to managing risk and ensuring the reliability of our system. With the ever increasing amount of real-time asset health information that is available to the asset manager, as well as all the traditional database type condition information obtained from preventative maintenance, the sheer amount of data can be challenging. Without a viable solution for turning that data into information that can drive repair replace decisions, the job of the asset will be difficult. This presentation will discuss PHI's approach to fleet asset health indexing and our partnership with Doble on the dobleARMS project.

The final portion of the presentation pertains to the health analysis of Dominion Energy's Large Power transformer fleet. This analysis drives a risk-based approach to maintenance plans, life cycle management, and proactive replacement. Transformers included into this plan are oil filled power transformers with a minimum rating of 7 MVA, and include primary winding voltages of 13.2kV to 500kV

Paul Griffin is Doble Engineering Company's Vice President of Global Professional Services. Mr. Griffin has been with Doble since 1979 and prior to his current role has held various positions including Laboratory Manager and Vice President of Laboratory Services. Since joining Doble, Mr. Griffin has published over 50 technical papers pertaining to testing of electrical insulating materials and electric apparatus diagnostics. He is a Fellow of ASTM and a member of Committee D-27 on Electrical Insulating Liquids and Gases. He was formerly ASTM Subcommittee Chairman on Physical Test, ASTM Section Chairman on Gases in Oil, and the Technical Advisor to the U.S. National Committee for participation in the International Electrotechnical Commission, Technical Committee 10, and Fluids for Electrotechnical Applications. Mr. Griffin is a member of the IEEE Insulating Fluids Subcommittee of the Transformer Committee.

Robert Allison is a Transmission & Substations Engineer III working for Dominion Virginia Power. Mr. Allison earned his Bachelor's degree in Electrical Engineering from Virginia Tech in 2007. He started his career with Dominion in 2008 at North Anna Nuclear Power Station as a substation equipment engineer. In 2009, his responsibilities expanded to include all nuclear switchyard equipment within Dominion's fleet of nuclear power stations. Beginning in 2012 he accepted a position in Richmond Virginia with Dominion Transmission Operations Engineering. Robert supports evaluation of equipment health and reliability, root cause failure analysis of large power equipment, transmission system risk analysis, and has served as an INPO Industry Peer for the purposes of sharing operating experiences, corrective actions, and lessons learned.

10:00 AM – 10:15 AM

Break

TP &

TM 10:15 AM – 11:15 AM

Measuring and Locating Partial Discharge in Transformer in Service

Falk Werner, Principal Engineer

Doble Engineering Company

Subject of the presentation is a transformer fleet PD assessment performed in the Caribbean in 2015. Measurement approaches and findings are laid out covering HFCT, RFI and acoustic PD testing. As a result of the assessment a transformer with defective cable L-bows was identified. In order to prevent failure of the equipment, those L-bows were inspected and significant deterioration was found within the connection.



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Falk Werner studied Electronics and Information Technology with a focus on Telecommunication and Signal Processing at the University of Stuttgart in Germany. His final thesis was Location of Partial Discharges by Means of Sensor Arrays. Mr. Werner has in-depth knowledge of partial discharge (PD) diagnostics and measurement methods on high voltage insulation systems. At Doble Lemke in Germany he co-developed the PD solutions range. Mr. Werner has several publications to his credit and is currently a Doble Power Services Engineer at Doble Engineering Company focusing on partial discharge, diagnostics and solution development.

RP 10:15 AM – 12:00 PM

Demonstration of Testing Transformer Protection Relay SEL 487E

Ed Khan, Director of Protection Testing

Doble Engineering

Ed Khan is with Doble Engineering Company. Mr. Khan has been with Doble for 10 years working in various capacities including Product Manager for protection tested related instruments. Currently, he is the Director of Protection R&D and Training at Doble. Prior to Doble, Mr. Khan has worked for GE, ABB, SEL, KEMA and others in various capacities. He has 36 years of experience in system studies, protection applications, relay design, power plant design, teaching and product management. He has a thorough knowledge about product development, protection, harmonic analysis, harmonic filter design, stability studies, real time digital simulations, generator protection and more. He has presented courses on behalf of GE and Doble in US, Southeast Asia, Middle East, Mexico, India and China. He also taught GE Protection course on few occasions. Mr. Khan is a member of CIGRE and is currently a member of the CIGRE Working Group B5.56 (Optimization of Protection, Automation and

TP &

TM 11:15 AM – 12:00 PM

Calculating Loss of Life for Transformer Assets: Challenges and Methodology

G. Matthew Kennedy, Solutions Director, Enterprise & Data Technology

Doble Engineering Company

G. Matthew Kennedy is Doble Engineering Company's Solutions Director: Enterprise and Data Technology, overseeing the complete software and cloud product vision of the company. During his time at Doble, Mr. Kennedy has had leading roles in the innovation and development of products such as the M-Series (M4, M5, M7), DTA, dobleARMS™ and dobleDATABASE™. With a keen interest in diagnostic technology, Mr. Kennedy has authored diagnostic analysis sections for international standards in addition to numerous papers, journal and magazine articles for the power industry. He holds a BS in Electrical Engineering from the University of California, Santa Barbara where he studied signal and digital signal processing. His post graduate studies continued with the US Navy: Nuclear Power School, University of Idaho in Electrical Power Engineering and Cornell University in Product Design and Development. He is a member of IEEE, IEC, USNC, and ISO.

TP-A 11:15 AM - 12:00 PM

High-Voltage Withstand Field Testing

Tom Melle, Manager

HighVolt



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Power transformer withstand testing is one of the most sophisticated processes undertaken to assess a transformer before it can be placed into operation. The full range of tests to be performed are very complex and the test systems must fulfill challenging demands. Ongoing technical progress in power electronics now gives transformer manufacturers and end-users access to static frequency converter (SFC) based power sources in the factory and field. These systems can provide a stable and virtually harmonic-free test voltage for a transformer test system. Because the output frequency can be freely adjusted, a wide range of AC transformer tests are possible. The main principles and applications of test systems for transformers with SFC-based power sources will be presented and explained.

Thomas R. Melle resides in Raleigh, NC having received a B.S. degree in electrical engineering from North Carolina State University. He has worked in the power industry as a Transformer Test Engineer and Project Manager. He now represents HIGHVOLT (Dresden, Germany) in the United States and Canada. He is active in several IEEE Committees, including Transformers, Insulated Conductors, and Power System Instrumentation and Measurements. Mr. Melle is presently Secretary for IEEE C57.142™, Investigation of the Interaction between Substation Transients and Transformers in HV and EHV Applications and for IEEE 1122™, Standard for Digital Recorders for Measurements in High-Voltage Impulse Tests.

12:00 PM – 1:00 PM

Lunch

TP &

TM 1:00 PM – 2:15 PM

Forensic Analysis

Root Causes of Failures: Bill Griesacker, Doble Engineering Company

Forensic Decommissioning: Anne Bailey, A-Line

Transmission Transformer Bushing Failure & Investigation: John Phouminh, Pepco Holdings

Generator Transformer Bushing Failure & Investigation: Samson Debass, Exelon Nuclear

Root Causes of Failure: Forensic examinations are conducted for a number of reasons; however, the end goal is typically to determine the root cause of the failure. Often this examination involves the review of historical operating conditions prior to the failure and the disassembly of the failed transformer in search of supporting evidence. Case studies will be presented.

Bill Griesacker is a member of Doble Engineering Company as a transformer engineer working on projects that include factory inspections, condition assessment, design reviews, failure analysis and general consulting. Mr. Griesacker holds an MS in electric power engineering from the Rensselaer Polytechnic Institute and a BS in electrical engineering from Gannon University. He is an active member of the IEEE, PES Transformers Committee where he holds positions in several working groups and subcommittees.

Forensic Decommissioning: Each transformer recycling project is unique based on the transformer design, location and circumstances for removal. This presentation will provide project examples to showcase on-site removal options and expectations as well as showcase the specialized equipment available to aide in the detailed assessment of power transformers. Project examples will include premature transformer failure



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assessment as well as procedures for obtaining samples during routine transformer replacement projects to aide in condition assessment initiatives.

Anne Bailey has been with A-Line E.D.S. managing transformer recycling projects for the past 10 years. She has experience contracting, evaluating and managing on-site transformer dismantling projects to provide turnkey services including the safe and environmentally sound disposal of power transformers including specialty services for forensic decommissioning.

Transmission Transformer Bushing Failure & Investigation: The objective of the presentation is to show how Pepco performed a typical apparent cause evaluation on a transformer failure. Our objectives were clear: to find out what happened, what the cause of transformer to fail and what we can do to prevent a similar failure from happening again. Knowing the root cause, we can apply the fix to a pool of extent of condition.

John Phouminh is a Principal Engineer in Transmission & Substation Reliability. He started his career with Pepco in 1989 as a technician. After graduating from college, he worked as a Substation Engineer. John has worked in different departments within the company during his career including the Customer Engineering, Distribution Standards, Failure Analysis & Maintenance Strategy, and now Transmission & Substation Reliability. John received his BSEE and MSEE from George Washington University in 1993 and 1995 respectively, and holds five PE licenses in four states and the District of Columbia.

Generator Transformer Bushing Failure & Investigation: Transformer failures do not always start in the main tank. Energized (Load) tap changers and bushings can fail and depending on the nature of the failure start or continue into the main tank. This presentation will be on a bushing failure mode inside the main tank.

RP 1:00 PM – 2:00 PM

Transformer Withstand Capability & Protection during External Faults

Mike Kockott, Senior Application / Product Specialist

ABB Inc.

The life of the power transformer depends on the life of the insulating paper, whose deterioration is affected by temperature, moisture, and gas content. The effects of moisture and gases can be controlled to a minimum level, leaving temperature as the primary culprit in paper insulation deterioration. The no load and load losses will generate heat which will in turn cause the transformer temperature to rise, and if not controlled, can cause damage to the paper insulation. In particular, as the temperature distribution inside the power transformer is not uniform, the paper insulation closest to the transformer hot spot will suffer the greatest degradation. Therefore, standards define transformer life as a function of the hot spot temperature.

Overcurrent elements generally need be set so high they cannot detect overload conditions in power transformers. Using standard guidelines, engineers can create continuous, long term emergency and short term emergency transformer ratings, and operators can use these ratings. However, there is a chance the transformer can reach critical hot spot temperatures during the overload condition.



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Transformer manufacturers guarantee the longevity of their product as long as it is operated under the temperature specifications given in the IEEE, and or IEC standards. These standards help us in calculating the effect of aging insulation and its exposure to high temperatures. The dynamic ratings for power transformers can be developed by calculating the loss of life and the winding hottest spot temperature. Such ratings can be used by system operators during contingency conditions, which will allow them to overload power transformers for a predetermined time. These transformer dynamic ratings can also be used to create settings criteria for thermal functions.

New numerical relays are capable of replicating the thermal models outlined in the Guides. The relay engineer can set thermal limits based on the dynamic ratings established by loss of life and winding hot spot calculations.

***Mike Kockott** is a Senior Applications / Product Specialist at ABB, NAM SA Products, located in Raleigh, North Carolina. He has been there since December 2011. Prior to this he worked as a Senior Applications Specialist / Senior Regional Technical Manager for 12 years at the SA Product factory in Västerås, Sweden. Before joining ABB SAP in Sweden in 2000, Mr. Kockott was Senior Consultant, Protection (Transmission) at Eskom (national power utility, South Africa and training engineer before becoming senior consultant, and rose to the position of Line Protection Design Manager.*

TP &

TM 2:15 – 3:15 PM

Developing Diagnostic Strategies through Understanding Field Test Results – Part I

Mark Lachman, Director of Diagnostic Analyses

Robert Brusetti, Director, Client Service Engineering

Doble Engineering Company

***Mark F. Lachman, Ph.D., P.E.**, has been with the power industry for over 30 years. In 2005, he joined Delta Star in San Carlos, CA, where, as Test Manager, he was responsible for the test department operation. In 2011, he returned to Doble Engineering Company as Director of Diagnostic Analyses.*

***Robert Brusetti** received his BS in Electrical Engineer degree from the University of Vermont in 1984 and a MBA from Boston College in 1988. He has been employed at Doble Engineering Company for twenty years and currently serves as Director of Client Service Engineering. Prior to his present responsibility he has held positions as Product Manager and Field Engineer. Mr. Brusetti is a licensed Professional Engineer in the state of Massachusetts.*

RP 2:00 PM – 3:00 PM

Modelling Withstand & Protection of Transformers under Fault Conditions— Software demonstration

Mark Y. Xue

FlexGrid Application LLC

When fault occurs in the vicinity of a transformer, high current could flow through the transformer. For out-of-zone fault, the transformer instantaneous protection should keep intact to allow the fault to be cleared by the corresponding zone relays and breakers. However, if the fault could not be cleared in time, which might be due to relay failure or breaker failure, the transformer could be damaged by thermal or mechanical stress produced



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by through fault current. Therefore, the transformer backup protection must be engaged to protect the transformer from sustained through fault current. The time delayed overcurrent protection is typically used for such purpose. For smaller transformers, the overcurrent relay might also be the only means for transformer protection. In the past, to make proper overcurrent pickup and time dial settings was not a trivial task. On one hand, the overcurrent relays must coordinate with all the adjacent line/feeder relays such that it will allow those relays to clear the fault in the first place. The overcurrent pickup setting should also allow the transformer to be temporarily overloaded to a certain degree. On the other hand, the overcurrent relay must trip if the through fault current lasts for too long. A relay engineer needs to balance the security and sensitivity under all the conditions. The modern software has made the relay settings much easier now. In this presentation, the definition of four transformer damage curves per IEEE standard will be explained and modeled on ASPEN Oneliner software. The process of making transformer overcurrent protection settings will also be demonstrated by using APSEN Oneliner software and a demo network. Various faults and protection response will be simulated to check the coordination. Through this demo, it is hoped that audience could have a good understanding of transformer withstand capability and the protection of transformers under through fault conditions.

Mark Y. Xue received his B.Eng. from Zhejiang University in 1993 and M.Sc. from the University of Guelph in 2007. He is the founder of FlexGrid Application LLC, a consultant company focusing on power system protection & control (P&C) engineering. In his employment history, he had spent 8 years with AEP, 3 years with GE, 10 years with ABB and 1 year with GEC-ALSTHOM. In AEP, he was a Principal Engineer responsible for P&C standards development, relay setting calculations, protection scheme design, mis-operation analysis, simulation studies, RTDS tests, R&D on special relay and software, etc. He was the lead engineer of CREZ - the largest transmission project in AEP history. In GE, he was the lead engineer in Application Engineering and Consulting Service Group and his responsibility included protection system design, RTDS simulation tests, relay setting calculations, customer training, research & development, etc. In ABB, he had designed and commissioned many protection and automation systems in US, Canada, China and Mexico. Mark Xue has presented over 10 technical papers for major relay conferences. He is a senior member of IEEE and a Professional Engineer registered in the state of Ohio.

3:00 PM – 3:30 PM

Break

TP &

TM 3:30 PM – 5:00 PM

Developing Diagnostic Strategies through Understanding Field Test Results – Part II

Mark Lachman, Director of Diagnostic Analyses

Robert Brusetti, Director, Client Service Engineering

Doble Engineering Company

RP 3:30 PM – 5:00 PM

Demonstration of Testing Beckwith Transformer Protection Relay

Ed Khan, Director of Protection Testing

Doble Engineering



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ALL 5:00 PM – 5:30 PM

Ask the Experts Panel – Anything Transformer Related

OPTIONAL LABORATORY SEMINAR

Friday, February 23, 2018

7:00 AM – 8:00 AM

Attendee Breakfast

7:00 AM – 4:30 PM

Registration & Information Desk Open

LS &

TM 8:00 AM – 4:30 PM

Transformer Condition Assessment Using Laboratory Diagnostics

Doble Engineering Company

David Koehler, Technical Manager, Doble Insulating Materials Laboratories

Paul Griffin, Vice President Global Professional Services

Melissa Zajac, Senior Manager – US Laboratory Operations

Harry Heulings, Senior Chemist

This one-day session provides students with a thorough understanding of how to assess the condition of electrical insulating materials and transformers.

Dissolved gas-in-oil analysis – This is the single most important diagnostic test for transformers. This presentation reviews how the test is performed, how to distinguish between normal gassing behavior and problems, and how to evaluate trends. Practical case studies and examples are used to illustrate theoretical concepts. Seminar participants will be quizzed (with class participation) on their understanding in diagnosing 12 cases.



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Water in Transformer Oil – Assessing how dry a transformer is requires more than a water in oil test. Learn how to assess the wetness of the transformer insulation system and why you need to know the operating temperature at the time of sampling. This session discusses water migration in transformers and how water affects the ability to overload them. Examples are provided.

Condition assessment of cellulosic insulation – The analysis of the condition of the paper insulation has changed quite a bit in the past 10 years. Learn how the solid insulation ages and how to assess the condition of the paper and pressboard insulation and its remaining life. Case studies are given to illustrate the distribution of paper aging in transformers and how operation and maintenance can influence it.

Metals in oil – This presentation provides an understanding of the importance of metal-in-oil tests as a diagnostic. To be able to use the information, the correct test must be specified – learn the difference between dissolved and particulate metals and when to choose each test. Case studies are given.

Quality of new and service aged oils – Background information is provided on the properties of transformer oil. The presentation includes how to specify and evaluate new oils, what tests to perform and how to evaluate in-service oils.

Aging characteristics of insulating materials - Aging is discussed in sections on oil and paper which provides information on how to increase the life of transformers. There are a number of factors that accelerate the aging of the insulation system that can be controlled. This session provides information on when to reclaim or replace oil and gives specifications for reclaimed oil.

Load tap changer and oil circuit breaker diagnostics – This presentation gives the latest information on diagnostics for load tap changers (LTCs) and bulk oil breakers. Case studies are provided.

Sampling – The presentation discusses how to save money on your sampling program through proper training and what common pitfalls to avoid. Proper sampling preparation, practices, and equipment are given.