



## The 76th Annual International Conference of Doble Clients Tutorial and Training Sessions

### **TUTORIAL: Bushing Design and Application**

*Sunday, March 29<sup>th</sup>*

*1:00 PM – 5:00 PM*

*America Ballroom Center & South, Westin Copley*

A good bushing design is imperative to the operation of the utility's electrical power system. A bushing's main purpose is to provide insulation for an energized conductor where it passes through the grounded plane of an apparatus tank. A bushing must be designed to handle electrical, mechanical, thermal and environmental stresses. This tutorial will provide the utility world with a greater appreciation and knowledge of bushing design and applications. The tutorial will cover the following technical information:

- History of the Bushing Design
- Critical Design Criteria of the following Bushings:
  - Oil Impregnated Bushing Design
  - Epoxy/Resin Impregnated Paper Bushing Design
- Draw Lead Verses Bottom Connected Bushing Design
- Horizontal Verses Vertical Bushing Design
- Design of Bushings for High Temperature Application
- Design of Bushings for High Contaminated Areas
- Design of Bushings for High Altitudes
- Porcelain Verses Composite Housed Bushing Design
- Bushing Tap Designs
- Factory Testing of Bushings
- Harmonics/Transients on a System and how it Affects a Bushing
- Purpose of Corona Rings
- Specification of the Correct Bushing for your Application
- General Panel Discussion

### **Keith P. Ellis, Trench Limited**

Keith P. Ellis graduated from Mare Island Navel Shipyard with a journeyman certificate in Machine Technology. Attended the University of California, where he majored in Mechanical Engineering. After serving with distinctions in the US Navy during the Vietnam War he continued his education at the University of Wisconsin, Milwaukee. Joined RTE-ASEA's engineering department at the onset of this new joint venture. While with RTE-ASEA he also worked as application engineer in Marketing and was then promoted to field sales for RTE and RTE-ASEA in Upstate New York. After nine successful years in field sales he returned to Waukesha to start up the OEM Components sales operation for ASEA, as Sales and Marketing Manager. When the Waukesha transformer operation was sold he was promoted to Sales Manager for the new ABB Power T & D Company's Components Division. He was then hired by Trench Limited to develop a line of IEEE/ANSI Standard bushings for the US market. Once the new bushings went into production in Canada he was promoted to Bushing Product Manager, Americas for the worldwide Trench Bushing Group. He is a member of IEEE, PES, Transformers Committee and past Working Group Chairman for C57.19.00. He takes particular interest in component applications to power transformers with special interest in high voltage bushings and on-load tap changers.



### **David M. Geibel, ABB**

Dave graduated with honors from the State University of New York at Alfred with an Associates degree of applied science in Electromechanical Technology. Dave graduated Magna Cum Laude from the University of Pittsburgh with a Bachelors degree of Science in Electrical Engineering. Dave worked for General Electric Company (GE) from 1974 until 1987. He started in the Plastics laboratory working on inventions like bullet proof window until 1976 when he moved to the high voltage testing laboratory for the Large Transformer Division. While at the High Volt lab, Dave performed design and development testing on a wide variety of electrical equipment (such as bushings). Dave did the first testing done by GE to determine why Type U bushing had rising power factor. In 1979, Dave transferred to the transformer design engineering department where he concentrated on load tap changer application and design. When GE sold the transformer technology to Westinghouse in 1986, Dave took a new assignment with a joint venture between Westinghouse and Reinhausen (MR) as the Quality Manager for the start up venture making load tap changers in North America. In 1988 Westinghouse asked Dave to join the field retrofit engineering group in Pittsburgh, PA where he was a Senior Design Engineer until 1996. At that time Dave moved to Alamo, TN to take the position of Fellow Development Engineer. In 2002 he was reassigned as Fellow Product Design Engineer for the ABB Alamo bushing business. In 2004 Dave became the Engineering Supervisor for Delta Star Inc. Dave returned to ABB Alamo in 2006 to take his current position as the Engineering Manager. Dave hold two bushing related US Patents.

### **H. Jin Sim, PE, Waukesha Electric Systems**

Jin has a BSEE from Dankook University in Korea. He attended two graduate schools for Engineering and one graduate school for Business Administration. He has been in the transformer industry for over 30 years in design, development, manufacturing, testing, and management. Currently, Jin is a VP, Chief Technology Officer for Waukesha Electric Systems. Jin has been active in the Electric Power industry as a past chair of several Working Groups and Subcommittees. Recently, he was the Chairman of the IEEE/PES Transformers Committee for 2002-2003 and currently chairs several Working Groups / Task Forces. He is a member of the US Technical Advisory Group for IEC Technical Committee 14, Power Transformers and an individual member of the CIGRE. He has been the NEMA and IEEE delegation to the ASC C57 Committee before it was discontinued.



## **The 76th Annual International Conference of Doble Clients Training Sessions**

### **TRAINING: BASIC PROTECTIVE RELAYING**

*Monday, March 30<sup>th</sup>*

*7:30 AM – 12:00 PM, 1:30 – 5:00 PM*

*Ed Khan, Doble Engineering Company*

The Basic Protection Relaying course is geared towards entry level engineers making their way into the field of relay protection and for technicians who like to obtain the theory and practices of protective relaying. The course is intended to provide a conceptual level of knowledge without the vigorous mathematical details.

The course will cover the following topics:

- Introduction to Relays.
- Differences Between Electro-Mechanical, Solid State and Microprocessor Relays.
- Current and Voltage Transformers
- Basic Overcurrent Protection
- Distance Protection
- Transformer Protection.
- Basics of Communication Assisted Protection
- Reclosing of Circuits
- Remote and Local Backup Protection

### **TRAINING: FUNDAMENTALS AND DIAGNOSTICS OF TRANSFORMER LOAD TAP CHANGERS**

*Tuesday, March 31<sup>st</sup>*

*7:30 AM – 12:00 PM*

*Steve Larson, Manager*

*Snohomish Public Utility District*

The Load Tap Changer (LTC) Fundamentals class will aid the participant in understanding how LTC's are constructed and operate. Components of the LTC such as moving/stationary contacts, reversing switch, collector ring, preventive autotransformer, leads and barrier board are identified and discussed. The various designs, such as arcing tap switch reactive & resistive, diverter switch resistive, transfer switch reactive, and vacuum bottle will also be explained, as well as comparing high and low side LTC configurations and series transformer types. Tap changer diagnostic testing (both on-line and off-line) and maintenance of LTC's will be discussed. This class will also describe how LTC controllers work, the meaning of settings, how to choose appropriate settings, test and troubleshoot them.



## **TRAINING: UNDERSTANDING TRANSFORMER NAMEPLATES**

*Tuesday, March 31<sup>st</sup>*

*1:30 – 3:45 PM*

*David L. Harris, P.E.*

*Customer Technical Executive*

*Waukesha Electric Systems*

This class will give recent utility personnel additions who may not have the experience reading the nameplates of transformers an introduction on the topic. How to identify the winding configurations and the load tap changer will be discussed. De-energized tap changers and cooling ratings will be described.

## **TRAINING: DC TESTING OF TRANSFORMERS – INSULATION AND WINDING RESISTANCE AND TESTING OF CORE GROUND**

*Tuesday, March 31<sup>st</sup>*

*4:00 – 5:30 PM*

*James R. White, Director of Training*

*Shermco Industries*

This tutorial will present information on dc testing of transformers, including insulation resistance, winding resistance and testing of a transformer's core ground. Although ac testing of insulation provides more accurate evaluation, DC testing is often performed on smaller transformers, especially dry-types. The winding resistance test is especially important when changing load-tap changers and for locating loose connections that are internal to a transformer and, therefore, inaccessible. Lastly, the core ground test ensures that the laminations are properly grounded so as to prevent circulating currents within the core, causing overheating and damage.

## **TRAINING: POWER FACTOR AND APPARATUS TESTING**

*Wednesday, April 1<sup>st</sup>*

*Theory, 7:30 AM – 9:00 AM*

*Keith Hill, Doble Engineering Company*

*Transformers and Bushings, 9:15AM – 12:00 PM*

*Arturo H. Oropeza, Doble Engineering Company*

*Circuit Breakers and Instrument Transformers, 1:30 – 4:00 PM*

*Linda Nowak, Doble Engineering Company*

The classes on power factor testing continue to be popular. To begin, the fundamentals of why the power factor tests are so valuable will be covered in the theory portion of this series of classes. The application of these tests will be explained for transformers, bushings, circuit breakers and instrument transformers. Case studies are included to show how apparatus problems have been found by applying the fundamentals of the theory.

## **TRAINING: SWEEP FREQUENCY RESPONSE ANALYSIS**

*Wednesday, April 1<sup>st</sup>*

*4:15 – 5:45 PM*

*Mario Locarno, Doble Engineering Company*

This year there will be training on the use of the Sweep Frequency Response Analysis technique. A review of the fundamentals will be covered and examples of apparatus problems will be shown.



## **TRAINING: DTAWeb**

*Thursday, April 2<sup>nd</sup>*

*7:30 AM – 9:30 AM*

*Marshall Turley, Doble Engineering Company*

Doble Engineering has implemented a system where Clients may store Doble Test Assistant data sets in a Doble Engineering database called DTAWeb. This system allows controlled access to the stored information over the World Wide Web. At this time there are over 800 users from over 200 Doble Client companies using the system. In this class the user of the system learn the benefits of this new system and how to maximize the features of DTAWeb.

## **TRAINING: PARTIAL DISCHARGE TESTING**

*Thursday, April 2<sup>nd</sup>*

*9:45 AM – 12: PM*

*Alan Wilson and Karl Haubner, Doble Engineering Company*

- (a) Introduction to the basics- what are partial discharges why are they important?
  - Partial discharges, causes, consequences
  - Examples of failures concentrating on Transformers, Machines, GIS, Cables
- (b) How a partial discharge develops physical changes that allow detection
  - Indirect methods using heat, light, sound, vibration, chemical changes and radiated electromagnetic waves
- (c) Applications of PD techniques
  - Measuring the electrical signals on line- using traveling waves and capacitance coupling in cables, machines and transformers and using electromagnetic probes to detect UHF radiation in transformers and GIS.
  - Off-line techniques used in the field

## **TRAINING: CAPACITOR BANK UNDERSTANDING, CONDITION ASSESSMENT AND FIELD TESTING**

*Thursday, April 2<sup>nd</sup>*

*1:30 PM – 3:30 PM*

*Doble Engineering Company*

With the increase of electricity demand, capacitor banks are suddenly everywhere with different sizes, arrangements and technologies. Often the maintenance personnel receives little information or training on how to deal with this apparatus, so they struggle to manage this asset, to monitor its conditions, or to troubleshoot a defective capacitor unit once it is mounted in a bank. This training starts off by introducing the capacitor technologies (fuse and fuseless), bank arrangements (parallel, serial, grounded and ungrounded), protection schemes and failure mechanisms. The class describes available test methods but will concentrate on the effective method, using the M4000 that Doble Clients already have. The test technique, called the Doble CapBank test, does not require disconnecting the capacitor unit during testing, so the technique can reduce testing time by 70% and may be performed during commissioning, maintenance or troubleshooting. Test procedures for different capacitor bank arrangements and data analysis will be covered to assess their condition and to manage this asset. Also, case studies of field testing will be discussed.