

Power Transformers Seminar

Drury Plaza Hotel
St. Louis, Missouri
May 17-19, 2010

Course Content:

It is often said that the life of a transformer is defined by the life of the insulation. Transformers are designed to operate for twenty years fully loaded. Most transformers exceed this design life, often lasting for twice this value. This course is designed to give the attendee a basic understanding of Power Transformer design, manufacture, operation and maintenance from a perspective of maximizing transformer life. By understanding the insulation system, operations and maintenance personnel can make informed decisions for purchasing, operating, maintaining and replacing power transformers on their system.

Transformer Design and Manufacture

H. Jin Sim - Waukesha Electric Systems

Power transformers are designed according to the specification provided by the purchaser and must include the manufacturer's design practice, and manufacturing capabilities. Typically each power transformer has its own unique design. In this presentation Mr. Sim will review the transformer design process including examples from his experience as a transformer designer. He will discuss the basics of transformer design and the effect on the insulation system. Insulation design criteria such as cooling and dielectrics will be discussed.

Special Session: Transformers for Wind Applications

Dr. Jan Declercq - CG Holdings Belgium NV

Transformers play a critical task in the economical delivery of this energy from the remote wind farms to the load centers. The operation characteristics of wind turbines place a unique burden on the wind power transformers. Power transformers designed for traditional grid applications are not well suited for wind farms. In this presentation Dr. Declercq will describe the design, performance, operation and maintenance issues that are unique for transformers for wind applications. Included is a description of the CG Power Systems "Slim Transformer" which is designed specifically for Wind Farm Applications.

Transformer Insulation

Thomas A. Prevost – WEIDMANN DIAGNOSTIC SOLUTIONS

The insulation system is a critical component of a Power transformer. In this presentation Mr. Prevost will review the basic functions which the insulation system must perform in a power transformer. Manufacturing practices will be reviewed which if followed will maximize the integrity of the insulation system over the life of the transformer. Insulation aging mechanisms will be reviewed so that they can be incorporated into operation and maintenance practices in order to maximize transformer life.

High Temperature Insulation Systems

Richard P. Marek - DuPont Protection Technologies – Energy Solutions

Cellulose insulation in Power Transformers is the limiting material from a thermal perspective. In this presentation Mr. Marek will discuss high temperature insulation systems. These insulation materials can be used with mineral oil or with high temperature dielectric fluids depending on the application.

Insulation Coordination

Vijay Pargaonkar – CG Power Systems Inc.

The electrical stress that the insulation system must withstand in a power transformer is very dependent on the protection scheme of the power system the transformer is connected to. It is important to coordinate the timing of fault protection in order to minimize stress on the power system. In this presentation Mr. Pargaonkar will present some of the basic concepts of insulation coordination and how it relates to transformer insulation design.

Factory Test

Krishnamurthy Vijayan - CG Power Systems Canada Inc.

Power Transformers are subjected to a series of acceptance tests in order to verify that the unit has been designed and manufactured to meet customer specification and applicable standards as well as to measure performance parameters that can be used in future loading criteria. These tests are defined in industry standards. In this presentation Mr. Vijayan will describe the standard acceptance tests used for power transformers including some details on future trends in the test requirements.

Factory Inspection

Jack E. Hammers, P.E. – Oklahoma Gas & Electric

Many transformer purchasers visit the manufacturer to inspect their unit in process. In this presentation Mr. Hammers will review the critical manufacturing processes in regard to what should be inspected to assure that the manufacturer is meeting the purchaser's expectations. Critical areas such as winding clamping, dielectric clearances, electrical connections, and proper mechanical support will be discussed with examples and photos included for illustration.

Shipping and Acceptance

Paulo Stein – CG Power Systems Canada Inc.

Transformer acceptance testing is performed to determine the condition of the transformer as it arrived on site. These include the repeat of some of the factory tests as well as a detailed review of the seismic shipping record. Acceptance testing also establishes a baseline of electrical and mechanical characteristics that can be compared with for the life of the transformer. In this presentation Mr. Stein will review specific test procedures which should be included in an acceptance test program.

Transformer Operation and Maintenance

TBD

In order to maximize the life of a transformer a purchaser must be involved in every aspect of the process from writing a proper specification, selecting an appropriate factory through design and manufacturing verification. After the purchaser has accepted shipment of the unit it is through his operation, maintenance and monitoring practices. This presenter will share experiences with transformer life enhancement from protection to maintenance and monitoring. Several case histories are presented which illustrate these points.

Transformer Loading

Donald Platts, P.E. - PPL Electric Utilities

Transformers are designed to last at least thirty years under normal operating conditions. In this presentation Mr. Platts will review loading philosophies and practices which have a direct influence on transformer insulation life. Many loading algorithms today depend on data generated during factory acceptance testing. This presentation will demonstrate how to find it and how it is used in the temperature calculations. Thermal limits on loading based on the phenomenon of bubble evolution and other criteria will be discussed.

Transformer Condition Assessment

Rick Ladroga, P.E. - Doble Engineering Company

Whether because of service age or abnormal operation, it is often necessary to assess the current condition of a power transformer. The information obtained by such an assessment can be used to decide whether to change the operation of the equipment (reduce load), perform maintenance or field upgrades, remanufacture, or replace the equipment. In this presentation Mr. Ladroga will review condition assessment methodology including the various tests which are typically included in condition assessments and what can be learned from these tests.

Field Processing of Power Transformers

Derek Baranowski – Baron USA

Whether due to atmospheric contamination or the byproducts of aging, the water content of transformers will increase with age. At some point it may be desirable to remove this moisture as well as any particles from the transformer oil. Mr. Baranowski will discuss the pros and cons of different methods of field processing transformers.

Transformer Failures/ Case Studies

William Bartley, P.E. – Hartford Steam Boiler

Although transformers are designed to withstand the severe operating conditions that exist on modern power systems, on occasion they do fail. In many cases we can learn from failures so that we can improve the specification or design criteria for future transformers. In this presentation Mr. Bartley will review a number of transformer failures, detailing the cause of the failure leading to a discussion of how prevention of future events could be accomplished.

Transformer Repair or Rebuild

Bruce Forsyth, P.E. – Southwest Electric Company

In many cases a transformer can be remanufactured so that it will have a life expectancy similar to a new unit. This is not always the case however. In this presentation Mr. Forsyth will review the remanufacture and renewal process. He will cover those critical areas which must be reviewed in order to determine if your transformer can be remanufactured so that it is as good as new.

Special Topic: HVDC Transformers

Waldemar Ziomek – CG Power Systems Canada Inc.

After the early battle between Edison and Tesla, Alternating Current has been used as the type of power utilized across the world. However direct current has advantages in certain applications such as long transmission distances and asynchronous system interconnections. HVDC converter stations require special transformers because of the combination of AC and DC electrical stress on the insulation system. In this presentation Dr. Ziomek will describe the special design considerations necessary for HVDC transformers.

Transformer Fluid Diagnostics

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May 20, 2010

Course Content:

OIL QUALITY ASSESSMENT

David Koehler – WEIDMANN DIAGNOSTIC SOLUTIONS INC.

Mineral Oil Composition

Dielectric Fluid Requirements

Chemical and Physical Evaluation of Dielectric Fluids

Over ninety percent of transformers are filled with mineral oil based dielectric fluid. Typical transformer fluid is a complex organic mixture that contains over 3600 different molecules. The role of any dielectric fluid is to transfer heat, provide insulation between components and to quench any arcs. The ability of a dielectric fluid to meet these requirements can be determined with a series of chemical and physical measurements.

Chemistry of Furans and Interpretation

One of the most significant parameters used to ascertain remaining life of transformer insulation is a measurement of the Degree of Polymerization (DP) of the insulation. This test is invasive, requires de-energization of the unit and removal of a test specimen. Determination of furans in oil has been developed as a non-invasive alternative to the DP measurement. Furans result from the partial degradation of cellulose insulation. They are soluble in oil, can be extracted from an oil sample and be quantitated. The concentration of furans can be approximately correlated with the important DP value.

CORROSIVE SULFUR

David Koehler – WEIDMANN DIAGNOSTIC SOLUTIONS INC.

Sulfur Compounds found in Mineral Oil

Testing for Corrosive Sulfur Compounds

Preventive Measures

Corrosive sulfur compounds in transformer oil have become a significant concern for system asset managers. Failures due to the presence of corrosive sulfur have occurred in several countries. The nature of corrosive sulfur compounds and their determination will be discussed. Proposed mechanisms for failures due to corrosive sulfur compounds will be reviewed. Also the mitigation of the corrosive sulfur problem with passivators will be explained.

ALTERNATIVE FLUIDS

Fredi Jakob – WEIDMANN DIAGNOSTIC SOLUTIONS INC.

Types and Chemistry of Alternative Fluids

Polychlorinated biphenyls (PCBs) have been controlled compounds since PCB production was halted in 1979. Alternative dielectric fluids that have higher flash points than mineral oils were required as PCB replacements. Biodegradability is also a very desirable fluid property. Natural ester dielectric fluids meet both of these requirements. The chemical, physical and environmental properties of natural ester fluids will be reviewed in detail.

DISSOLVED GAS ANALYSIS (DGA)

Fredi Jakob – WEIDMANN DIAGNOSTIC SOLUTIONS INC.

Insulation Decomposition

History of DGA

Laboratory Procedures

On-line DGA

DGA Data Interpretation

Case Histories

During the last thirty years Dissolved Gas Analysis has emerged as the single most useful tool to assess the condition of transformers and other oil filled electrical equipment. The theoretical basis of DGA will be described. Laboratory and on-line DGA methods will be discussed. Interpretation of DGA data will be thoroughly reviewed. Case histories will be examined to illustrate the application of various diagnostic protocols.

LTC and OCB Diagnostics

Karl Jakob – WEIDMANN DIAGNOSTIC SOLUTIONS INC.

DGA principles for newer applications such as LTC and OCB diagnostics will be presented.