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US EXPERIENCE ON CONDITION ASSESSMENT OF VARIOUS TYPES OF TAPED CABLE SYSTEMS BY DISSOLVED GAS ANALYSIS BASED ON A NOVEL SAMPLING AND ANALYSIS TECHNIQUE

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ABSTRACT

The Dissolved Gas Analysis (DGA) technique, which has been successfully applied to transformers, is being increasingly considered for laminar dielectric cable systems. To enhance the effectiveness of the DGA technique to such cable systems, however, proper sampling, analysis and interpretation methods have to be developed taking into account not only the markedly differing field conditions but also the distinct characteristics of the fluids and constructions involved in the two products.

This paper describes a novel sampling and analysis method and its extensive application to the US underground transmission system. The system is characterized by easy-to- use, light, inexpensive disposable vial that serves both as the sampling and analysis vessel.

KEYWORDS

Dissolved-gas-analysis, disposable-sampling-analysis -vial, field-data, underground-transmission-cable.

INTRODUCTION

Laminar dielectric underground transmission cables, which are an integral part of the electric power system, represent considerable utility investment. It is imperative to protect this investment through proper maintenance to avoid unscheduled outages. Following the successful transformer practice, the Dissolved Gas Analysis (DGA) technique, is being increasingly considered for taped transmission cables.

The majority of the US underground transmission circuits are based on HPFF (high pressure fluid filled) cable systems, with a modest representation of HPGF (high pressure gas filled) and SCFF (self contained fluid filled) cable systems. The earliest cable systems installed in the 1920s were SCFF at 138 kV. The HPFF cable systems, introduced in the 1930s, became the predominant choice in the subsequent decades. The HPGF cable systems, which were introduced in the early 1940s, have received recent renewed interest due the absence of free dielectric fluid. Unlike HPFF and SCFF cable systems, the HPGF cable systems are limited to 138 kV level because the gaseous pressurizing medium (Nitrogen) does not provide sufficient dielectric strength at voltages above 138 kV, as compared to the liquid dielectric. It is estimated that the present total circuit lengths of installed HPFF, HPGF and SCFF cables respectively are 4,250, 300 and 400 miles. It should be noted that about 45% of US HPFF cable systems are over 35 years old.

While predictive and preventive maintenance have always been recognized, the present-day utility business climate brought about by increasing competition and deregulation calls for the maximum trouble-free utilization of such assets. It is essential to protect this large investment, amounting to tens of billion of dollars, through proper maintenance to avoid any unscheduled outages, all the more as a significant percentage of these cables is advancing in age. DGA is universally applied to power transformers and has proved quite effective in the condition monitoring of such equipment. While the transformer DGA experience is quite useful, particular attention to cable DGA with respect to sampling, analysis and interpretation has to be paid due to inherent differences in the design, materials and operating conditions relating to the two types of equipment. These differences include type of fluids and their viscosities, cellulosic materials, thermal and electrical stresses as well as operating pressures. Accordingly, the DGA behavior of cables is different from that of transformers and this also holds amongst various types of cables and their accessories.

DGA relates to the analysis of various gases – lower and higher hydrocarbons, hydrogen and carbon oxides – that are generated under electrical and thermal stresses experienced by an operating cable. These gases remain dissolved in the dielectric fluid (unless the saturation level is exceeded) in a liquid state, loosing all semblances to a gas, hence the name “dissolved” gases. The type, distribution and concentration of such gases are governed by the specific nature of the electrical, thermal or mechanical problems faced by a cable, giving cues to the condition of an in-service cable. The success of DGA depends on sampling, analysis and interpretation. The collected sample should faithfully represent what is within the cable and no gases should escape or add to the sample during handling, transportation and analysis. Gases with low solubility such as hydrogen and carbon monoxide tend to escape. The high concentration of nitrogen from pumping plant can lead to bubble formation as the pressure is significantly reduced in the sample that is invariably taken in a glass syringe. Such bubbles present difficulties in the analysis, further compounded by the escape of low solubility gases into these bubbles. The relatively high viscosity of dielectric fluids associated with HPFF cables further add difficulties in sampling, all the more in winter months. The handling of the collected sample involving the extraction of gases and subsequent transferring to chemical instrumentation, can lead to errors.

To overcome some of these difficulties, a previous sampling and analysis approach, called the EPOSS (EPRI Pressurized Oil Sampling System) method, was specifically developed for taped cables by Detroit Edison under EPRI (Electric Power research Institute) sponsorship in the mid-