DGA (Dissolved Gas Analysis) Value in Detecting and Locating Potential Problems in Laminar Dielectric Cable Systems

Nirmal **SINGH**, Sandeep **SINGH**, Rommy **REYES;** DTE ENERGY, (US), nirmal.singh@dteenergy.com, sandeep.singh@dteenergy.com, rommy.reyes@dteenergy.com
Eduardo **MARTINEZ**, Hawaiian Electric, (US), eduardo.martinez@hawaiianelectric.com
Elino **JULIAN**, American Electric Power, (US), eajulian@aep.com
Milan **UZELAC,** G&W Electric Company, (US), muzelac@gwelec.com
Tiebin **ZHAO**, EPRI, (US), tzhao@epri.com

ABSTRACT

This paper covers the application of DGA to HPFF cable systems. DGA identified a potential fault in a 138 kV GIS (gas insulated switchgear) termination due to excessive acetylene, including problems at 345 kV GIS terminations based on acetylene level. It enabled the location of a potential fault within a 138kV splice housing, as revealed by the observation of a hydrogen peak at 102,520 ppm that was established by means of fluid draining-cum-sampling process for DGA. This paper includes supporting laboratory investigations relating to acetylene generation in a point-plane configuration and paper layer sandwich incorporating metal filings under electrical stresses.

Keywords

DGA, Fault Detection/Location, HPFF cables, GIS & Outdoor terminations, Splices, Acetylene, Hydrogen Peak, Field & lab data

INTRODUCTION

The Dissolved Gas Analysis (DGA), which has been successfully employed to assess the condition of power transformers since the early 1970s, is being increasingly applied to high voltage laminar dielectric cable systems. DGA has come to be recognized as a reliable and economic diagnostic method for assessing the health of such underground transmission systems, effectively covering terminations, splices, cables per se, trifurcators and risers of high-pressure fluid-filled (HPFF) and high-pressure gas-filled (HPGF) cable systems, also referred to as pipe-type cables. DGA also offers great promise for monitoring the condition of high voltage extruded cable terminations containing a dielectric liquid.

One of the merits of this approach is that it can take care of and differentiate between the various individual components of the pipe-type cable system for diagnosis. Pipe-type cable systems constitute nearly 85% of the US underground transmission, and such cables are advancing in age, placing increasing focus on reliable and economic diagnostic tests. The estimated total circuit-length of such cables rated 69-345kV is nearly 5,500 miles in the US, with over 50% of circuits exceeding 50 years of service, hence the need for a reliable diagnostic method.

Recognizing this situation, EPRI (Electric Power Research Institute) sponsored a comprehensive research and development effort into cable DGA at the then Detroit Edison Company (now DTE Electric Company) in the early 1980s, and this work is continuing for both laboratory and field investigations. The transformer DGA pre-dates cable DGA. However, the latter has received sustained attention for broad research relating to sampling, analysis and interpretation along with the contribution of cable fluids and papers to gas generation under controlled thermal and electrical stresses, including solubility studies in different cable fluids. This had been prompted by the need to extent the prior established DGA transformer experience to cables, whose design, operation and materials are different. Cable DGA started receiving attention in the mid-1980s in the US and its use became extensive in the early 1990s. It is hard to imagine an HPFF cable-circuit, where DGA is not regularly performed on its components in the US.

This paper covers the application of DGA to GIS terminations, outdoor terminations, splices, and cables per se, with focus on problem cases that have been followed over several years by the authors. Excessive acetylene provided the basis for the indication of potential problems, in GIS terminations, and this acetylene was in accord with other expected key hydrocarbon gases. As the evolved gases tend to remain at the site of generation and move as the dielectric liquid is moved, advantage was taken of this unique gas feature to successfully establish location with the highest content of gases and potential fault initiation point through fluid movement by following hydrogen or acetylene. This resulted in the observation of a hydrogen peak along the splice housing/cable pipe in two cases. To the best of our knowledge, such a significant finding has not been reported earlier. Fluid movement through draining was also used in tracking acetylene for the mentioned GIS termination.

Lab tests and correlation to field findings

Acetylene is deemed to be the single, most important gas, and its evolution is attributed to an electric arc. Accordingly, acetylene generation was studied in a point-plane configuration in a fluid volume under impulse conditions, demonstrating that acetylene will be only generated when an electric arc, howsoever feeble and minute, occurs, but visible. In addition, acetylene evolution was also addressed in a fluid-immersed high voltage flat electrode arrangement bounding a paper-layer sandwich with minute metal filings under ac conditions as a function of voltage and time. The observation of a small concentration of acetylene was always accompanied by the charring/blackening of paper with slight damage around the metal filings. This demonstrates that a relatively low level of acetylene will lead to paper damage in the paper layers of the termination insulation.

This was corroborated by the opening of the three 345 kV HPFF GIS terminations. The extent of paper damage