Condition Assessment of Pipe-Type Joints Utilizing Limited-Angle Computed Tomography X-Ray Technology

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ABSTRACT

For utilities, reliable power delivery is a necessity and is achievable with periodic inspections of electrical infrastructure. High-Pressure Pipe-Type underground transmission feeders exhibit linear movement that can compromise their integrity and lead to failure. Consequentially, to recognize critical failure indications and issue immediate remedial action, assessment of these joints is vital.

This article describes the process from concept validation to the testing of a fully engineered innovative application of Computed Tomography and three-dimensional imaging to enable volumetric inspections of underground feeder joints. This technology is a transportable field solution implementable without service shutdowns in a limited angle of movement environment.

KEYWORDS

High-Pressure Fluid Filled Cable, Underground Transmission Feeders, Joint Maintenance Inspection, Pipe-Type Joint Movement, Three Dimensional Computed Tomography, Pipe-Type Joints, Portable High Energy Digital Inspection System.

INTRODUCTION

With the growing demands of today placed on our existing infrastructure, keeping public utility systems fully functional is more challenging than ever before seen in our history. This is especially evident in major cities where millions of individuals and businesses are heavily reliant on the installed electrical grid.

The reliable delivery of energy to businesses, medical facilities, communication systems and residential locations is critical and failures can, and do, create disastrous consequences.

Today, the power industry continues to provide safe uninterrupted services to their customers by diligently assessing their critical infrastructure challenges. The City of New York, with a population of over eight million people, served by Consolidated Edison Company of New York, (Con Edison) was looking for the next dimension of safety for critical infrastructure.

Over time, High-Pressure Fluid Filled underground power transmission feeders move back and forth in a predominantly linear fashion from a few inches to as much as several feet.

This motion is caused by several different factors including variations in the electrical power load placed on the transmission feeders, which has a direct impact on the thermal expansion and contraction of the feeders. For example, a transmission feeder installed in the winter months will see a significant variation in stress when the summer time temperatures arrive, prompting the wide use of air conditioners and placing a greater electrical power load on the feeders than is the case in the colder winter months.

Other factors that can cause motion or stress on pipe-type transmission feeders is the effect of gravity as it pertains to elevation. Meaning, the weight of the transmission feeder, 45-67 kg/m (30-45lbs/ft), is going to place a physical load on the feeder over differences in elevation over a distance, basically, pulling the feeder downhill so to speak.

Also contributing to these issues is seismic stress and the impact of vibration from traffic in the roadway above the underground transmission feeders and on the adjacent subway lines.

All of these motion variables can, over time, affect the quality and reliability of the joints in the feeders and potentially compromise the integrity and effectiveness, which could ultimately lead to a catastrophic failure if gone undetected.

These mechanical stresses applied to the transmission feeders as a result of thermal expansion and contraction or movement will disturb the metallic shielding present in the joints and lead to high electrical stresses at these points, which will compromise the integrity of the insulation around the conductors, particularly in the area of a joint, causing eventual failure of the joint.

When detected early enough, the joint can be repaired, saving time and money and minimizing collateral damage due to an actual cable failure which could result in the need to replace a substantial length of cable between two existing joints at much greater cost and down time, as opposed to just a localized joint repair.

When potential problems are identified, immediate inspections can be performed without shutting down power or risking further damage and outages. To provide the most accurate inspection, and inspect these joints in place, an innovative solution was required.

With this in mind, Con Edison, together with the selected inspection service company, also based in New York, implemented a pilot program to employ Limited Angle, Three Dimensional (3D) Computed Tomography (CT) technology to rapidly inspect selected areas of the power grid to determine if preventive action was required.

THE THEORY

The goal was to develop a transportable field solution using High Energy X-Ray generation, digital imaging detectors, and specialized imaging software to detect possible flaws.

The result was an innovative gantry system making it possible to obtain limited angle, three dimensional and