Analysis of Frequently Failed Transmission Lines in India and Innovative Solutions for the Better Operation and Maintenance of the Towers

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ABSTRACT

Supply of continuous power will be the most important aspect of a transmission line network during emergency time. Many Transmission Lines in India are constructed long time back. So, they are having old aging transmission system life and aging equipment which leads to higher probabilities of failure, higher maintenance cost and higher replacement cost. So, aging equipment needs to be replaced and this replacement should be planned in coordination with capacity additions in any. As the demand for power is increased and various technological development has been tested and approved for better equipments to be selected with reference to the geographical location and weather condition of the line routes. Nowadays, many high voltage transmission lines have been developed worldwide and are successfully being operated in developed nations.

In Indian transmission scenario are progressing towards establishing 765 KV lines to strengthen in recent trends its transmission infrastructure. Massive expansion of the inter-state transmission system is under way to provide to the transmission requirement of new generation projects. Transmission line failures occur due to harsh weather and non-climatic reasons such as human errors and mechanical failures. While it is impossible to prevent all such situations, electrical utility officials and contractors must be equipped to meet such emergencies. Emergency Restoration System Towers were a temporary solution designed to bypass the existing transmission towers of any voltage in any terrain. They will be used until the main line is re-conductored or restored. Planning includes determining which transmission lines are important and the possible ways in which they can fail and how best to restore them. This includes general information about existing structures and foundations, data on past weather related failures, weather criteria and structural loading and the extent of damages. To compound this difficult situation, large amounts of inventory were required in order to have spare lattice towers available for emergency restoration work. In India, Power Grid Corporation of India inherited more than 100 different types of designs of transmission suspension towers and transmission tension or dead-end towers. In this paper, it has been analysed for various reasons for frequent failure of transmission lines in various parts of India. Also, analysed various necessity for the transmission line utilities to take precautionary actions to avoid and reduce these disruptions. Then discussed about various recent innovation technologies and transmission components which can be used for the better operation and maintenance of the transmission lines in Indian conditions and standards adopted.

Key Words: Transmission Line, TL Failures, Operation and Maintenance, Innovative Technology

1. Introduction

All the high voltage transmission lines are exposed to a certain level of damage risk, threatening to disrupt or impair critical power supply infrastructure and affect public safety. Utilities cannot avoid these emergencies, therefore, it is important to know their cause and quickly, efficiently respond to the problem

on timely manner. Emergency situations may include failure of structural systems and foundations, failure of conductor splices and damage to conductor strands leading to conductor failure, etc. Transmission line tower damage may also occur due to degradation of conductors due to wild fires, flood, insulator breakage, failure of cross-arms and buckling of tower angle members or connection failures.

Transmission line maintenance is a frequent process and involves cleaning insulators, the elements located at the top of the tower which hold the cables that transport power (conductors). In order to get rid them of dust and other particles suspended in the air that build up, operators spray them with pressurized demineralized water. To do so, they have got to climb the 35- to 50-meter-high tower structure beforehand or go up in a crane to place themselves in front of them. This maneuver sometimes also entails replacing broken components with new parts.

2. Objectives

High voltage transmission lines carry electrical energy from power generating stations to long distances and reaches substations. These transmission lines are passing through a wide range of terrains, climates and physical environments and are always at risk to experience catastrophic events, both weather-related and man-made. Weather-related events include high winds, ice buildup, ice storms, flash floods, rock or mud slides, erosion of foundations, etc. Sudden power failures caused by nature are very common, however, non-weather related events are just as likely. These events include human error, vehicle accidents, vandalism, terrorism, design faults and poor maintenance practice.

3. Methodology

Due to the vast expanse of India and the variation of the weather conditions, Power Grid Corporation of India is subjected to transmission lines that occasionally fail due to natural disasters. These natural disasters are a result of mudslides, heavy ice, cyclones and floods. Traditionally, restoration of these transmission lines was completed using existing spare of normal towers. The typical self supporting lattice type towers used in India were erected using derricks and in some cases a complete new foundations has to be constructed. These processes are very time consuming and often resulted in prolonged outages. In many of the sites of these damaged transmission structures were difficult to access physically. The loss of these towers would sometimes result in backing down the generation and load shedding at industrial area in India. When major natural disasters occurred, it was calculated that lost Gross Domestic Product for India could be eighteen times the value of the power that was lost.

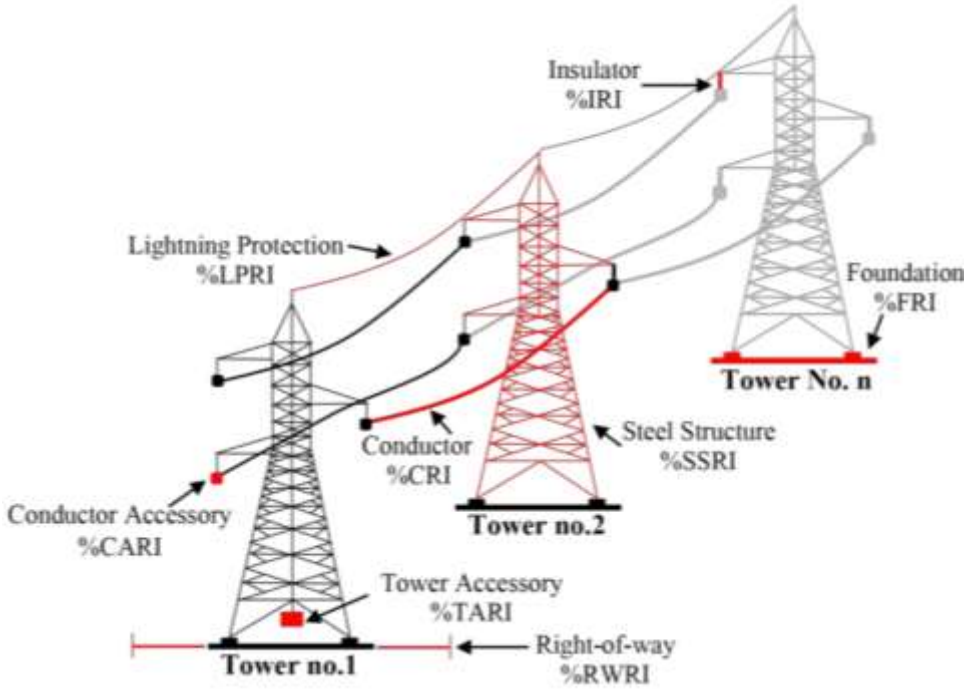

Figure 1: Various Transmission Line Components for maintenance

Transmission line inspections are carried out either by walking in the terrain or from the airborne every one to three years. The following issues, among others, are observed in the inspections as

1. Vegetation in the transmission line area, new structures, excavations
2. Possible inclination of tower structures, condition of steel parts, bird's nests, woodpecker holes
3. Integrity and condition of insulators and conductors.

Special inspections are also carried out whenever necessary, such as decay damage in towers, earthing, insulators and couplings.

4. Analysis and Discussion

When a high voltage transmission line goes down with one or several damaged towers, the responsible utility agency incurs huge monetary losses and hundreds of non-transmission hours. Given that the total losses and damages are directly proportional to the outage duration, time is a crucial factor in reinstating or remediating the failed towers. In some cases, the process of formally rebuilding a new line with original towers can take as long as 5 to 6 weeks.

Figure 2: Typical Transmission Line failure in many places

However, by using an effective Emergency Restoration Plan, the filed transmission structures can be replaced in a few hours depending on the nature and depth of the damage. Proper planning benefits not only for maximizes restoration efficiency but can also minimize inventory levels.

An effective Emergency Restoration Plan contains three essential elements like Planning, Emergency Materials and Training. To perform any quick emergency restoration work, critical materials must be readily available for installation. The inventory must include standard wire sizes in sufficient quantities as may required more. If the line consisted of poles, then the inventory stock must have a reasonable number of poles of similar size and strength of the same line. Structures used for restoration work can be modular, temporary or permanent type.

An important role of any restoration is the training of field workers in the erection of the replacement structures, stringing and guying operations. A prompt mobilization of the trained work force is vital to the process of emergency restoration.

In the real application of the tilt monitoring system, by establishing and verifying various theoretical calculation models among environmental information such as the inclination angle of the transmission line conductor, the inclination angle of the insulator tower, the ambient temperature, humidity and the wind direction, the inclination of the tower is given to improve the system and the accuracy of the calculation.

Figure 3: Maintenance of Tower components in using tilt monitoring system

The restoration process consisting of simple design with standard weather criteria for the re-route, which required towers and other materials shifted to the affected site.

Normally, a double circuit line will be transferred to three sets of ERS towers with two towers in each set thereby forming a double circuit. Surveying and transportation of huge materials to site is a major challenge. The real challenge will be installing the anchors as we can see at the time of the standard towers. If the soil is too soft that it was not suitable for installing any type of anchors. Modular supports were specially designed by considering the guy angles and transportation to the site easily. In ERS towers, the long modular steel supports offer the large width, which is necessary for both connecting the guy wires and also increasing the stability of the ERS structure installed.

One of the noteworthy features of ERS structures installation are easy and quick. The ERS structures does not require any foundation and can be set up on any soil type. The base of the tower contains a four meter box upon which strong metallic angles can be built. These towers are light in weight and can be transported easily using helicopters or manually.

5. Challenges and Innovative Solutions

Traditional power transmission tower maintenance mainly depends on regular inspections and human observations, which are very necessary safety protection methods. However, these methods have certain subjectivity and some parameters are difficult to measure by manual method. It is not easy to find problems in real time and cannot meet the constraints of real-time monitoring of the tower.

The restoration process consisted of the determining the cause of failure as due to the galloping, replacing the existing hardware fittings and adding more vibration dampers to the conductors to increase the damping.

The three restoration activities discussed above highlight the importance of utilizing obtainable inventory, creating quick construction methods, deployment of temporary structures and why conformance to design protocols is critical to avoid hardware failures.

Figure 4: Maintenance using Innovative Technology

Even after carrying out condition monitoring and preventive maintenance, the break-down of transmission lines cannot be ignored, mainly because of natural calamities. Restoration of damaged and collapsed transmission line tower can take a very long time which can vary from three to four weeks depending on site conditions, availability of spare towers, requirement of pile foundation etc. Because of the Power Grid has been deployed the IEEE Standard 1070 Emergency Restoration System for restoration of failed towers. Manual erection of the ERS tower takes minimum of three to four days when restoring a collapsed tower. When hydraulic cranes or helicopters can be deployed, the restoration work can be done in 2-3 days time.

Since acquiring the emergency restoration systems, Power Grid has used these systems many times for either emergency restoration on transmission line or maintenance activities. The results to date have met all of Power Grid's expectations. As a result of Power Grid's preplanning for potential emergencies on their regional grids, major savings have been achieved by both the Power Grid and by the economy of India. From the experience to date, Power Grid has modified their emergency restoration program by keeping emergency restoration materials which have been made more decentralized throughout India in their regional offices in order to reduce the deployment time.

6. Conclusion

In all these cases, the utility demand is to restore the power system to normalcy rapidly. The primary concern in Emergency Restoration is to revive the transmission network, get the line back into normal operation as quickly as possible and to restore electricity supply to the affected consumers at the earliest. Another important concern is to minimize the economic impact of the costs associated with the devastation and rebuilding. While total the cost to rebuild or restore a failed transmission line is inversely proportional to the restoration time, the total losses are directly proportional to the outage time. Therefore, one can view any Emergency Restoration Plan as a combination of technical or engineering processes with the financial planning.

Use of composite insulated cross arm will reduce the cross-arm load on the structure and also the clearance required for insulator swing. These towers are best suitable to maintain uninterrupted power supply, when tower failure occurs. These ERS towers bypass the original transmission system to restore power at the

earliest, while the original tower is being rectified. These towers are very much useful for restoring power supply following various natural disasters for conducting scheduled maintenance work on the existing towers without much interruptions.

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