MANAGING TRANSIENT INTERRUPTIONS ON AGED 22KV OVERHEAD LINES IN TNB DISTRIBUTION NETWORK THROUGH ENGINEERING PRACTICES ASSESSMENT AND INSULATION COORDINATION GUIDELINES

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ABSTRACT

TNB has to deal with 1,000 km of 22kV overhead lines that have been in service since 1940's. As with any ageing asset, performance of these 22kV overhead lines tends to deteriorate. From fault analysis, about 40% of the interruptions are caused by transients and about 60% of these transient interruptions are weather related.

Rehabilitation and replacement has been planned for these ageing assets. However, such plans require years to materialize as resources such as budget, material, and manpower needs to be well-planned and executed so that the rehabilitation and replacement plan is efficiently implemented. Thus, TNB still needs to maintain these ageing assets so that their performance is still acceptable to TNB customers.

In order to maintain these 22kV overhead lines, Engineering Practices Assessment has been adopted in order to assess the health of these ageing assets. The above methodology is used because it helps TNB engineers to assess these 22kV overhead lines holistically so that any threat that is considered as a risk to the performance of these 22kV overhead lines can be detected. Once the threat has been detected, relevant mitigation action can be deployed.

As 60% of the transient interruptions on these ageing 22kV overhead lines are weather related, an Insulation Coordination Guideline for TNB Distribution Overhead Lines is used as the reference point to improve the performance of these ageing 22kv overhead lines. TNB engineers are exposed to the concept of CFO or critical flashover voltage, proper lightning shielding, optimized placement surge arresters, effective grounding, effect of contamination on overhead lines dielectric strength, and importance of air clearance.

This paper attempts to illustrate the effectiveness of the above combinations as more than 80% of transient interruptions on these ageing 22kV overhead lines have been reduced between January 2010 and July 2010.

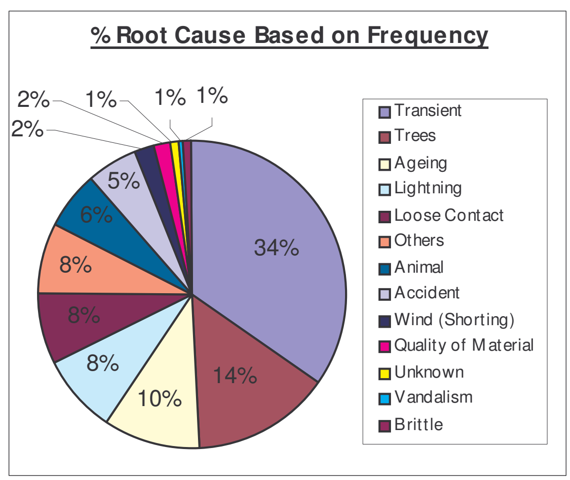
INTRODUCTION

It is a common fact that transient interruptions on distribution overhead lines cannot be eradicated. Thus, the strategy that utilities usually embarked on is to mitigate transient interruption so that the risks it poses to the security and reliability of distribution overhead lines can be minimized.

Next, it is imperative that the threats that lead to transient interruptions needs to be properly identified. With the threats become known, utilities can identify what resources and arsenal that they have and need to mitigate those transient interruptions.

Typical Interruptions in TNB Distribution

To mitigate transient interruptions, dominant causes of distribution overhead line failures need to be identified before any tasks can be initiated so that appropriate risk assessment criteria can be developed to help strategize the mitigation plan.



Graph 01: Typical Overhead Line Failure Causes

From Graph 01 above, it shows that transient is the leading cause for distribution overhead line interruptions in TNB

[1]. Since transient interruption is only momentary and supply to customers is restored within seconds, it is not regarded as a major risk. Transient interruption will only become a threat when it happens more frequently and starts to become a nuisance.

Due to the nature of transient interruption, post-interruption analysis to determine its causes is not often done. Moreover, lightning and other natural phenomena such as heavy rain and strong winds are often blamed for the high numbers of transient interruption. This misconception often leads to believing that transient interruption is uncontrollable as human cannot control natural phenomena such as lightning. Thus, post-interruption analysis is not necessary. Unfortunately, the root cause of any transient interruption cannot really be determined without any extensive fault investigation. It should also be acknowledged that other major causes can and may contribute to the high number of transient interruptions. For example, temporary touching of tree branches on overhead lines could also cause transient faults. Similarly, other major causes such hot-spot due to loose contact, ageing installation, animal encroachment, human encroachment etc. can all contribute to those transient interruptions.

From the above observation, TNB strategy is to categorize these threats into 2 major threats:

a. Controllable threats
b. Uncontrollable threats

Threats that can be controlled include vegetation encroachment, animal encroachment, human encroachment, ageing installation, loose contact, and quality of material. Naturally, threats that are considered uncontrollable are environmental phenomena such as lightning, strong winds and heavy rain. By categorizing these threats as above, it becomes more manageable to mitigate transient interruptions. And with that, the next step is to develop a strategy towards reducing transient interruption.

Strategies for Transient Interruption Mitigation

The strategies used to develop activities in mitigating the two major threats as mentioned above include the followings:

a. Employing Engineering Practices Assessment in managing Controllable Threats;
b. Employing Insulation Coordination Guidelines in mitigating Uncontrollable Threats

Engineering Practices Assessment

Site confirmation with respect to the conditions of the distribution overhead lines that can include their installation, health level, nearby land use activities, and rentice up-keeping is vital to determine if potential threats that can lead to transient interruption are present. Thus, in order to achieve the above, Engineering Services Unit of the Distribution Division has developed an initiative termed "Engineering Practices Assessment" or EPA.

EPA main objective is to educate and assist stations on how to detect threats that can lead to transient interruption and to recommend improvement strategies based on the observations and findings during the assessment. EPA is also an initiative to promote successful engineering practices adopted by a particular station so that other stations can emulate those best practices.

Insulation Coordination Guidelines

A study by TNB Research, Universiti Tenaga Nasional and Distribution Division, TNB in 2008 produced a comprehensive guideline entitled ***"Guideline in Insulation Coordination Practices for Medium Voltage Overhead Distribution System"***. The main area of concern in improving the overhead line performance against lightning includes the following aspects [2]:

a. Determining distribution overhead lines that sits in high lightning prone areas;
b. Determining insulation strength of overhead lines;
c. Measuring of soil resistivity and improving pole footing resistance;
d. Familiarization of overall insulation coordination design including shielding, arcing horns, and optimum placement of surge arrester

Although lightning incidences are very active in Malaysia, stations need to determine that the overhead lines are really exposed to the threat of lightning before focusing their effort to properly coordinate the overhead line insulation strength. In order to do that, stations needs to get GPS coordinates of the overhead line being assessed and superimpose it to a Lightning Map as shown in Figure 2 below that can be obtained from Lightning Detection System in TNB Research Lightning Lab[3].

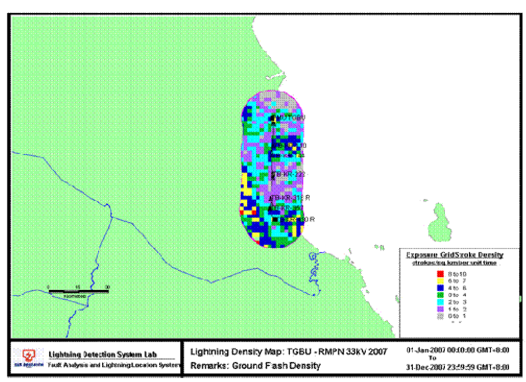


Figure 02: A Lightning Map of a Distribution Line

Once it is confirmed that lightning is the main threat that leads to frequent transient interruption, only then stations can embark on the following activities:

a. Tower or pole footing improvement;
b. Shielding improvement;
c. Surge arrester optimized placement;
d. Insulators critical flashover voltage improvement

MITIGATION ACTIVITIES

With the strategies for transient interruption mitigation in place, the next step is the actual mitigation activities based on the EPA and the ***Guideline in Insulation Coordination Practices for Medium Voltage Overhead Distribution System.***

EPA Mitigation Activities

Mitigation activities to manage controllable threats that fall under EPA include the followings:

a. Vegetation management deployment
b. Animal guard deployment
c. Hot spot detection of poor contacts or connections
d. Ageing component replacement

Vegetation Management Deployment
Vegetation Management System (VMS) involves the use of the 3-Cut Method to ensure delayed re-growth or to stop re-growth entirely by involving the natural healing process of the trees and vegetations [4]. With VMS deployment, transient interruption caused by trees can be reduced as threats from tree branches are properly controlled.

Animal Guard Deployment
One of the challenges faced with overhead lines running through jungle areas or plantations is animal encroachment that can include rodent, monkeys, birds, and snakes. "H-Pole Dressing" can be employed to reduce breakdown and transient interruption caused by animal encroachment. A typical h-pole dressing currently employed in TNB is as shown in Photo 01 below:

Photo 01: An Example of H-Pole Dressing

Hot-Spot Detection
Hot-spot, culminating from poor contact, is also a threat that can be considered for contributing to the high incidences of transient interruption especially on expulsion-type drop out fuse. When a drop-out fuse is exposed to hot-spot, the fuse rating tends to be de-rated. For example, a 10-A fuse can be de-rated to 2A when exposed to hot-spot. Because of this, whenever load picks-up during the day, this de-rated fuse tend to trip. Such incidence is also considered as transient interruption since whenever the fuse is replaced, no actual tripping occurs. An example of hot-spot detection of a drop-out fuse assembly is as shown in Photo 02 below:

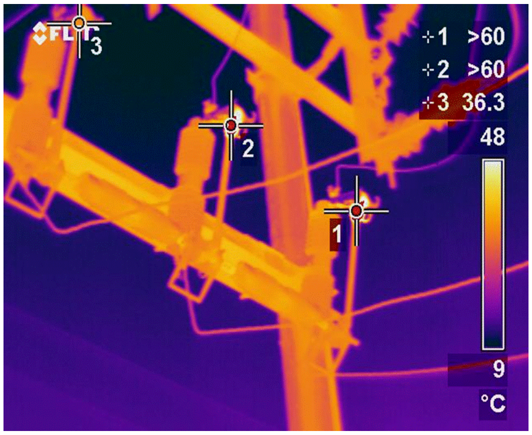


Photo 02: Hot-Spot Detection on EDO Fuse Assembly

Ageing Component Replacement
Ageing component replacement is replacing those components that have exceeded their service life but are still installed in the system. These components are still in service due to the fact that they do not show any deterioration through visual inspection. However, components like porcelain insulators may have lost their dielectric strength but cannot be detected through visual inspection as porcelain insulators are known to have good mechanical strength. Thus, all ageing components that are more than 25 years are replaced regardless of the condition. As shown in Photo 03 below, some porcelain insulators manufactured in 1934 that were still installed in the system:

Photo 03: Use of Porcelain Insulators from 1934

Insulation Coordination Mitigation Activities

Some of the major activities that are deployed to manage uncontrollable threats that have caused numerous transient interruptions on the 22kV Overhead Lines include the followings:

a. Tower or pole footing improvement;
b. Shielding improvement;
c. Surge arrester optimized placement;
d. Insulators critical flashover voltage improvement

The use of the Insulation Coordination Guideline has helped improve the installation techniques of surge arresters on the 22kV overhead lines systems so that these surge arresters can function properly to protect the overhead lines. Moreover, failures of the surge arresters due to wrong installations can also be minimized [5].

Aside from that, extending the automatic circuit recloser (ACR) dead time from the usual 3 to 5 seconds to 15 to 25 seconds has also helped in reducing transient interruptions by allowing those temporary faults to be cleared first before the ACR recloses.

RESULTS

With all the above mitigation activities carried out, encouraging results are achieved. One success story comes from the state of Perak. A comprehensive program to mitigate transient interruption was initiated on 12th October 2009. The results are as follows:

No	Feeder	08/09	09/10	Post EPA
1.	SBGS 4L5	19	9	0
2.	PAPN G31	20	8	0
3.	KHAN 4L5	9	4	0
4.	BDOR 9K5	5	2	2
5.	KGJH 8K5	9	10	0
6.	MFM 3L5	3	5	0
7.	BSIA 4L5	4	3	0
8.	GRIK 2L5	2	2	0

Table 01: Transient Interruption Statistics in Perak

Major activities that were done include the following:

a. Transient Interruption Awareness Program;
b. Engineering Practices Assessment on Top 10 Worst Performing Feeders;
c. Mitigation Activities on Top 8 Worst Performing Feeders;
d. Installation of Automatic Circuit Reclosers with Extended Dead Time Setting at Strategic Location;
e. 100% Pole Top Inspection;
f. Ageing Asset/Component Rehabilitation Operations;
g. Infra-Red Thermography for Hot-Spot Detection;
h. Vegetation Management Deployment;
i. Automatic Circuit Reclosers Counter Reading.

CONCLUSION

From the above results, it can be deduced that transient interruption can be mitigated with the use of correct strategies and approaches. Although at the initial stage, the task to reduce transient interruption tend to be very challenging, having the knowledge of possible threats that can lead to transient tripping helps in developing the required action plans.

The combined use of Engineering Practices Assessment (EPA) and Insulation Coordination Guideline is very encouraging not only to mitigate transient interruptions, but also to improve the general performance of overhead lines against other potential threats than can lead to a more severe breakdown. The use of EPA helps make the process more manageable by first analyzing asset performance statistics and relevant details. By categorizing threats into controllable and uncontrollable threats, effective mitigation activities can be put in place to reduce transient interruptions.

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