FIELD EXPERIENCE OF DIAGNOSIS TECHNIQUES FOR DETECTING DAMAGED INSULATORS OF OVERHEAD DISTRIBUTION LINE

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ABSTRACT

Because f increasing dependence of electricity in economi c growth, it is important to reduce the number of interrup tion in distribution line. KEPCO have more inspection on distribution line and have chosen to utilize diagnostic too ls such as infrared thermography, ultrasonic and UV cam era now than before. Patrol or simple visual inspections c onsists of walking, driving by equipment to identify obvio us structural problems and hazards such as leaning poles , damaged equipment, contact something. It is necessary t o use handhold detectors for correctly detecting insulatio n defect during a patrol. The aim of this paper is to identi fy electromagnetic signal emitted from defected and dama ged insulations on 22.9 kV distribution overhead line. The results obtained during the field inspections are compare d with that of verification test carried out at High voltage laboratory. From the comparisons of these results the effe ctiveness of each technology applied to the field inspectio n is obtained. The results show that diagnosis equipments have the quite different sensitivity to identify the defectiv e insulators with environmental condition and its types. B ased on the available knowledge for defective insulators i t is much more economical carried out distribution line in spection.

INTRODUCTION

Distribution network operators are today faced with the di fficult task of keeping networks up despite reduced reven ue while at the same time guaranteeing appropriate and ge nerally accepted reliability of networks. Because of increa sing dependence of electricity in economic growth, it has become important to reduce the number of interruption in distribution line. Typical distribution line patrol inspectio n in terms of the types of defects had been done to simple visual inspection. It is necessary to use handhold detector s for correctly detecting insulation defects during routine l ine patrol. KEPCO have conducted more inspection and h ave chosen to utilize diagnostic tools such as infrared ima ging, ultrasonic and UV camera now than before. In this p aper, the property of diagnosis equipments is investigated based on field experience whether it can identify electrom agnetic signal emitted from defected and damaged insulat ions on KEPCO distribution overhead line. The results ob tained during the field inspections are compared with that of verification test carried out at high voltage laboratory. From the comparisons of these results the effectiveness of each detector applied to the field inspection could be obt ained.

Overhead line inspection

Figure 1 shows the result of cause analysis on distribution line interruption. The number of line faults can considera bly reduce in scheduling line inspection. Patrol or simple visual inspection consists of walking, driving by equipme nt to identify obvious structural problems and hazards suc h as leaning poles, damaged equipments and broken insul ators.

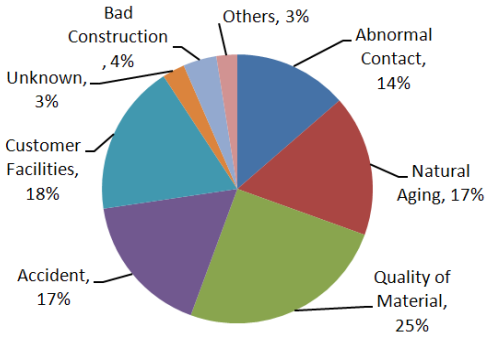

Figure 1: The causes of interruption on distribution line o f KEPCO

Table 1: Inspection interval of equipment installed in KE PCO's distribution network

Items		Inspection Interval
Compon-ents	Pole Transformer & Switch	2 or 4 years - Urban, Industrial : 2 years - Rural : 4 years
	Pad Transformer & Switch	One every 2 years
	Lightning Arrester	Required or Inspected
Other Equipm-ent	Wires	Required or Inspected
	LV Connector	One every 10 years
	Insulator	Required or Inspected
	Cable Head	Required or Inspected
Under Ground Units	Manhole/Power ca ble tunnel	One every 2 years Pumping out & Cleaning
	Cable Bridge	Required or Inspected

Table 1 shows inspection and maintenance plan intervals

of KEPCO's distribution network. Distribution lines have been inspected by ground patrol a minimum of once every 1-2 years. For economic reasons, the use of diagnosis methods is not considered for distribution network in the past. Using of diagnosis equipments is become more economical and convenient to conduct field inspection at present. Remote inspection devices which are used for ground patrol in KEPCO are infrared thermal imaging, ultraviolet imaging and ultrasonic discharge detector. Inspection of distribution overhead lines has been performed with a qualified person from KEPCO academy.

Detection of defective components

KEPCO is applying an optical telescope, thermal camera, High frequency corona & ultrasonic detector and UV detector to overhead distribution network inspection. At the first step, High frequency corona & ultrasonic detectors are used for roughly detection to network components that have highly possibility of faults. These detectors are reproduced as audible sounds for practical usage and portable convenience. Secondly, its detailed inspection is performed with an optical telescope, thermal camera. If it is found to damaged or estimated bad components, those are dismounted and sent to a research centre to experimentally evaluate its properties. Finally, it is improved the method and criteria to identity detected equipments in overhead distribution line.

FIELD DETECTION

Inspection equipments

Ultrasonic detector

Because it is the critical factor of detection results, ultrasonic detection equipment which has center frequency adjustable from 35 kHz to 45 kHz is selected with a serious consideration. Ultrasonic detector is extremely useful conducting nondestructive examination of porcelain insulators.

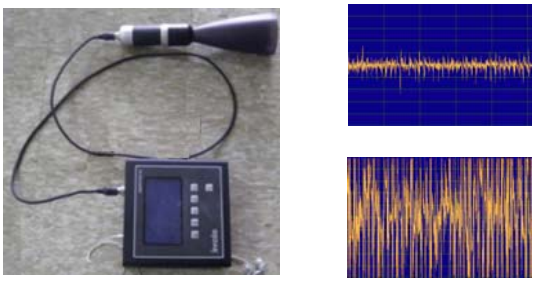

Figure 2: Ultrasonic detector and waveforms (upper–normal insulator, under-defected insulator)

Especially, it detects well flaws in outdoor porcelain insulators such as line post, switchgear bushing, cut-out insulator. In KEPCO, it's generally accepted the most economical solution because ultrasonic sensor can detect a damaged insulators at speeds up to 30~40 km/h for over head distribution line inspection.

Figure 2 shows the ultrasonic detector and an example of ultrasonic wave. We have found out flaws with the criteria expressed in decibel (dB). Waveforms which are collected with high resolution transducer have used to reference data for the higher probability of correct decision. We could build well foundation of ultrasonic detection if we can choose good equipments, detectors, and correct detection parameters based on long field experience. And also, the Sensitivity and frequency of the detector should be adjusted in the same set value for correct decision.

The data in figure 3 shows that the ultrasonic properties of defective ceramic insulator have been changed with the temperature. It shows the higher rate of detection during the summer season rather than winter season. Although sound energy become generally known that is absorbed by humidity, the ultrasonic detector is used to inspect distribution line didn't have direct influence.

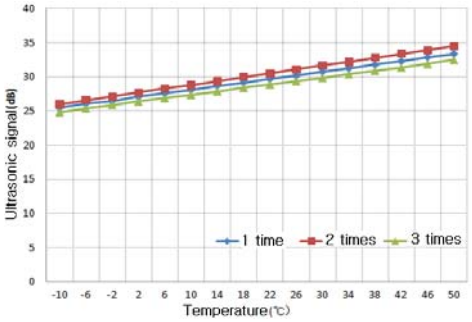

Figure 3: Temperature dependence of the amplitude of ultrasonic signals transmitted through the air

Figure 4 shows that amplitude of signal detected by ultrasonic detector was inversely proportional to sensing distance. If low-level discharges are emitted from defected insulators in distribution line, it is very difficult to detect that by the ultrasonic detection.

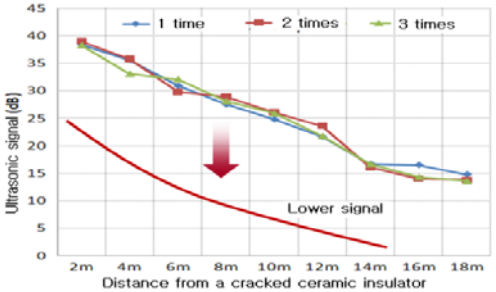

Figure 4: Amplitude of ultrasonic signal detected verses sensing distance

Thermal image

The infrared imaging technique is effective and simpler te

chnique for detecting the defect insulators. We have used to locate overheating joints, increased leakage and poor li ghtning arrester with the rise in temperature. Thermal ima ge camera mounted on vehicle or carried by hand can be a cquired more feature values at night than in the daytime, but visual image in the daytime. We have avoided shiny s urfaces in daylight to reduce the probability of misdetecti on.

UV detector

The MultiCAM System provides a simultaneous video im age of an infrared spot and corona in distribution equipme nt. This information assists the user in determining the loc ation of the hot spot and/or corona and also, by a close ex amination, it's possible cause. Since the video provides a moving image, it is possible to determine the seriousness of the hotspot. UV detector is insufficiency for verifying correctly defective insulators on KEPCO distribution line up to now. We need to have more field experience and tec hnical information.

Inspection process

The first step is to conduct a rough detection with high fre quency corona and ultrasonic detectors that are hand carri ed or vehicle mounted. As the second step, a qualified per son is to perform a detailed inspection with an optical tele scope and thermal camera. Defective insulators are dismo unted from a pole and sent to research laboratory for expe rimental evaluation. Finally, it is the most important work to document the field data and to modify the detection cri teria. As these data of line inspection and monitoring are key activities in ensuring asset integrity, we are especially pay attention to analyze, judge and make correct evaluati on.

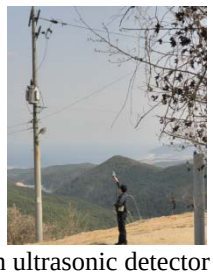

Figure 6: Field inspection with ultrasonic detector

Documentation and System input

The person performing distribution line inspection could move to one and another pole 30~40 km/h of speed with high frequency corona and ultrasonic detectors. The imag es and signal from the detectors were saved in its hard dis c, and at the same time, some information is transmitted t o the server by wireless access point. Two types of docu ments are using for statistical analysis of resultant that ha s performed inspection in the field. One thing is general it ems such as detecting value, weather condition and geogr aphical locations. The other is analyzing the historical dat a and detailed information about the equipment's conditio n obtained from inspection, monitoring and maintenance r ecord.

Limitation of detection

The conventional examination of overhead lines is mainly checking the internal and surface deficiencies of porcelai n insulators and porcelain shells. The common internal no ndestructive examination is ultrasonic and high frequency examination. The other detection methods such as therma l imaging and UV detection are not suitable for low leaka ge current condition. Ultrasonic examination can detect th e cracks buried inside porcelain insulators and porcelain s hells. The other methods could not do this due to be detec ted only the weak signal on the ground. Through field ins pection with an ultrasonic detector and an optical telescop e we can find out over 90 % crack position located in cera mic line post. Table 2 shows factors such as field conditio n and inspector to affect the detecting efficiency. The fact or affecting on diagnosis precision has been recorded and utilized to correct each criteria.

Table 2: Factors to affect efficiency of the fault detection in field inspection

	Affection factors
Field conditions	sun light, temperature, humidity, rainfall, wind speed and direction construction of pole
Inspector	distance and direction speed of vehicle state of equipment

CONCLUSIONS

The use of visible/infrared/ultraviolet imaging devices an d ultrasonic detector for inspecting the health of distributi on line is well known and widely accepted in KEPCO. W e have detected abnormal signal emitted from insulators with local damage such as micro crack, void, tracking and surface contamination.

Thermal imaging display good detection property at night in good weather condition and avoid detection in direct s unlight. *Ultrasonic* is no correlation between detection va lue in dB and the degree of defect. If we detect the signal on ground level, there is a high possibility of defect. The magnitude of detected signal was affected by direction an d distance from inspector. In some case, it was used to det ect normal discharge from pole transformer or switchgear. Now, by combining above inspection techniques into one instrument significant savings in time and cost can be ac hieved to make predictive maintenance faster, safer and m

ore cost effective.

Because it emit a very weak signal on defective polymeri c insulators in good weather condition, there are very diffi cult to detect. KEPCO is now making optimal inspection guidelines for polymeric insulators. Diagnosis equipment s have the quite different sensitivity to identify the defecti ve insulators with environmental condition and its types. Based on the available knowledge for detecting property and defective insulators it is much more economical carri ed out the distribution line inspection.

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