Case Study

Leonardo ENERGY

Power Quality Control in an Industrial Estate

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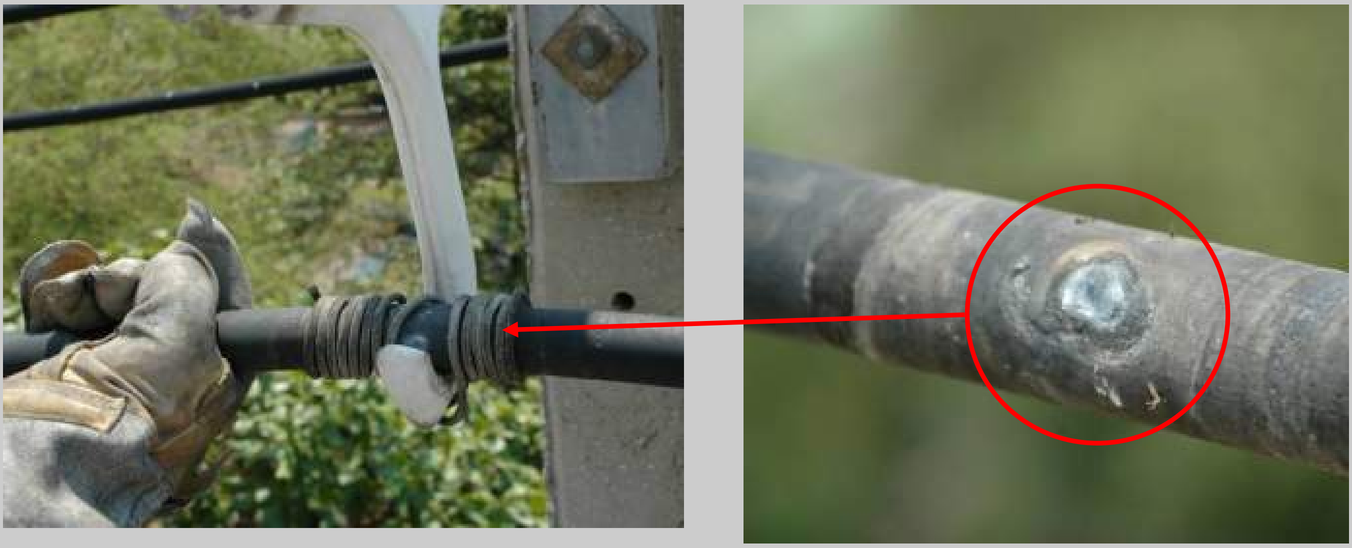

Power Quality

Abstract

This paper presents a methodology for improving power quality in an important industrial estate. A project was initiated to reduce the number of interruptions and enhance power quality in the estate and focused on reducing weak points in the power distribution system by inspecting distribution lines in both customer and utility areas. Once weaknesses were identified, corrective action would be taken and preventative measures taken to prevent re-occurance in order to provide high power availability to customers.

1. Introduction

A substation supplies power to factories in an industrial estate through 24 kV feeders. The substation has two 60 MVA transformer to step down from the 115kV external transmission lines to 24 kV. Note that the 24 kV busses from each transformer are separate; they are not connected to each other. See Figure 1 for a single line diagram.

2. Problem and consequence

There are a significant number of customers connected to each 24 kV feeder. If there is a short circuit in any feeder, all customers on that feeder will lose power (see Figure 2) while customers on the other feeders may experience a voltage dip (see Figure 3). In general, more customers will experience a voltage dip than will lose power. The consequences of a voltage dip will vary from customer to customer depending on the sensitivity of their equipment and processes.

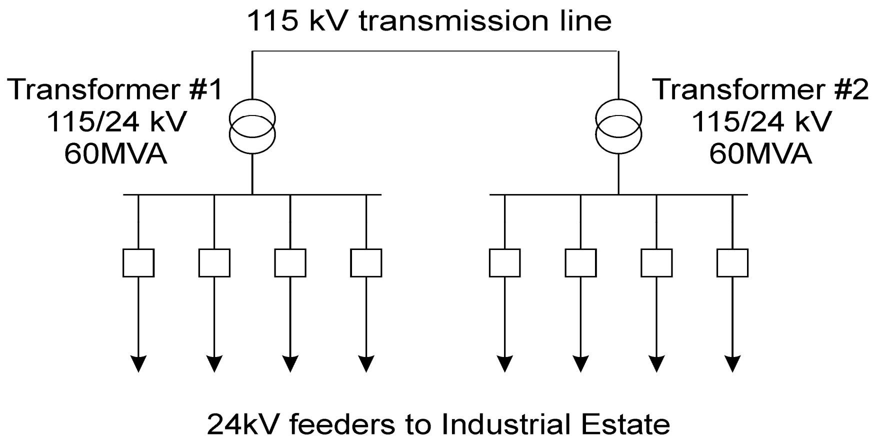

Figure 1: *Substation and Feeder system 24 kV at Industrial Estate*

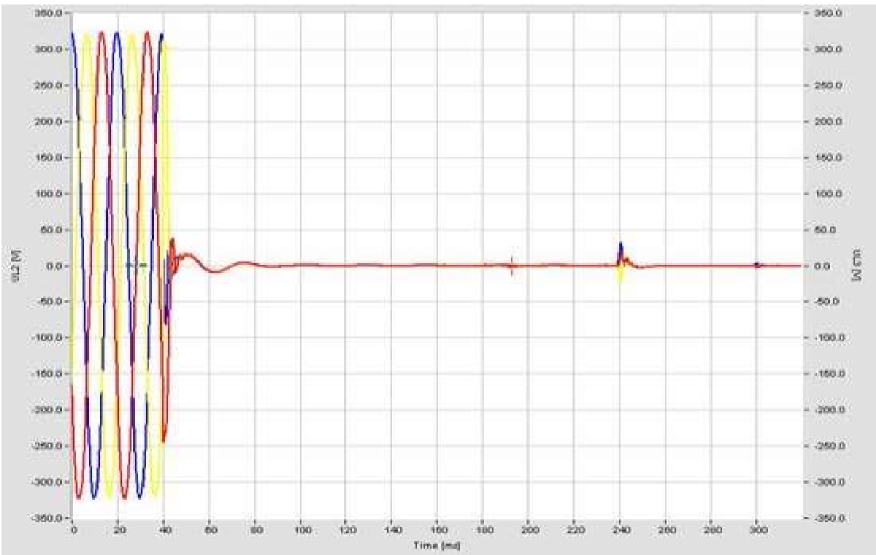

Figure 2: *Electrical waveform when power interrupted*

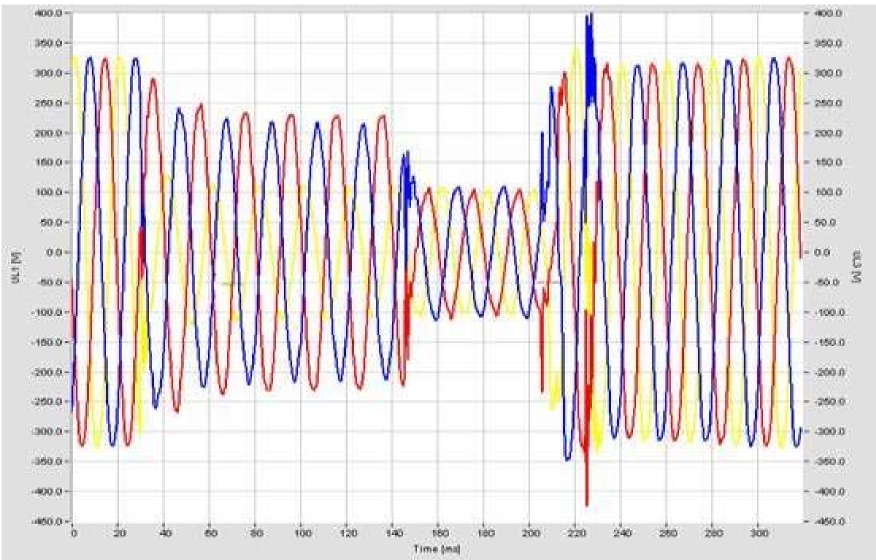

Figure 3: *Electrical waveform during voltage dip*

3. Monetary loss

Most of the factories in the industrial estate operate continuous processes, such as the manufacture of aluminum cans. The loss due to each voltage dip is between 3,000 and 5,000 Baht (60 and 100 Euro) while for each interruption it is between 100,000 and 200,000 Baht (2,000 and 4,000 Euro). However, from the utility perspective, the loss of opportunity in selling electricity to the entire complex may be as high as 200 million Baht (4,000,000 Euro) per year.

Figure 4: *Deterioration of cable insulation which is close to a cooling tower.*

4. Root cause of the Problem

All feeders in the industrial estate are of the overhead type. The wiring system components, such as insulated cables, hinges, transformers, drop fuses, insulators, and lightning poles will deteriorate over time due to the actions of heat, humidity, and other environmental factors. This deterioration may cause short circuits and lead to power quality problems**.**

5. Problem analysis

Normally, the gradual deterioration of equipment is unavoidable so preventive maintenance is very important to ensure that breakdowns and failures are avoided. Using better quality equipment, correct installation techniques, and avoiding external factors (such as illustrated in Figure 5) which can promote deterioration help to protect the system from degradation.

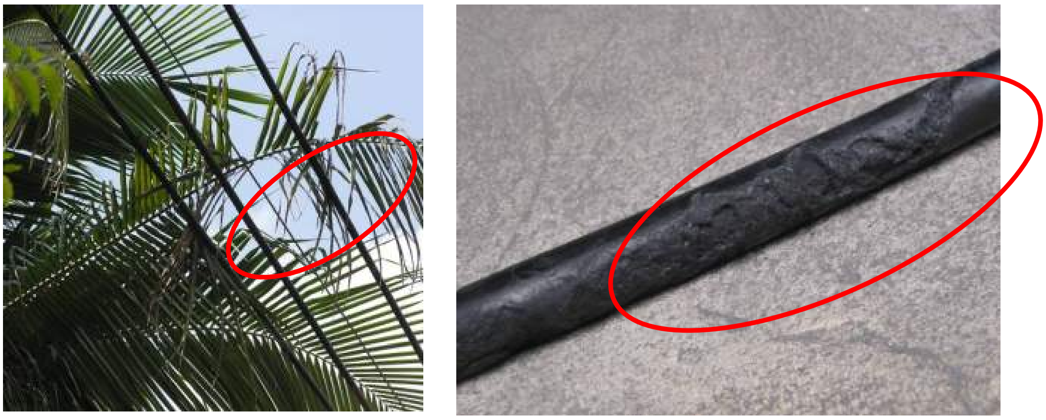

Figure 5: *Insulated cable intermittently touching a tree (left) leads to deterioration of insulation (right).*

6. Solution

Preventive maintenance and the use of proper equipment.

For example, pin-type insulators and spacers have a short lifetime and are not suitable for use in 24 kV systems because of their poor insulation properties and rapid deterioration. Figure 6 shows a ceramic spacer after two years service. This promotes partial discharge phenomena and degrades the cable insulation (see Figure 7). A pin-post-type insulator, as shown in Figure 8, has better insulation properties and is more durable to outside environment.

Figure 6: *Gray coating was removed (left) and change to be orange color* (right).

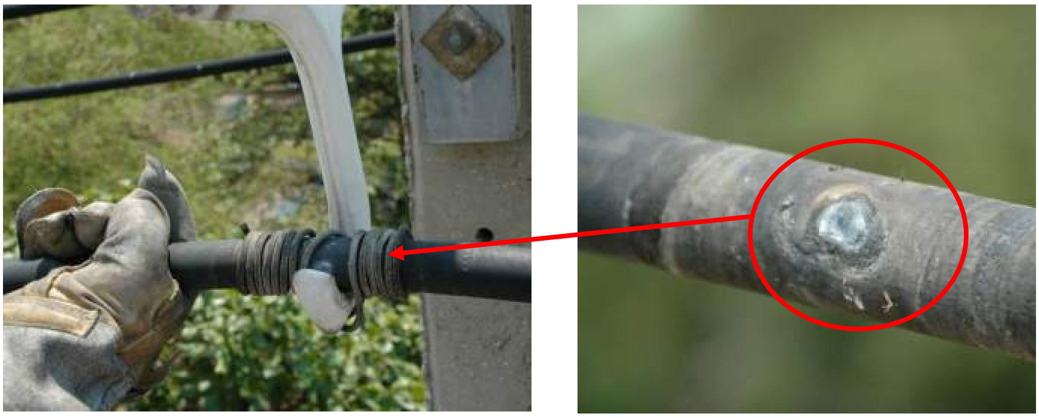

Figure 7: *Partial Discharge site (left) and resultant cable damage (right).*

Figure 8: *Installation of Pin & Post insulation (left) to replace a spacer (right).*

Locating problems by visual inspection, partial discharge detection and thermal imaging.

Visual inspection by an expert will quickly identify general deficiencies, such as insulator damage, improper installation, and broken or damaged equipment. Non-visual methods, which are more sensitive, can be used to detect problems before they become serious.

For example, detection of partial discharges – which may lead to breakdown of the insulation – can be detected by non-contact acoustic or optical methods, as shown in Figures 9 and 10 respectively.

Figures 11 and 12 show the use of a thermal scanner and its inspection result. This instrument easily finds connection points that are at a higher temperature than surrounding areas, quickly locating hot spots. Once a problem has been identified and corrective action completed, a maintenance plan should be put in place requiring at least two annual inspections.

Figure 9: *Acoustic partial discharge detector.*

Figure 10: Optical partial discharge detector (left); partial discharge caused by cable touching a tree (right).

Figure 11: *Thermal imager (left) in operation (right)*

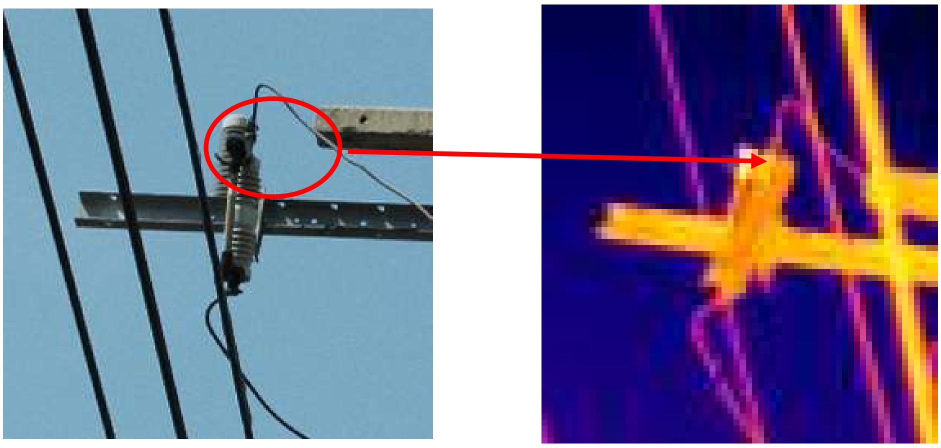

Figure 12: *Elevated temperature at the top contact point of a fuse.*

7. Expenditure

An inspection exercise takes about 20 days and costs 330,000 Baht (6,600 Euro) while repair and maintenance takes 90 days and costs 665,000 Baht (13,300 Euro). Therefore, the total expenditure is 995,000 baht (19,900 Euro).

8. Conclusion

Year to year comparison shows a 22% reduction in short circuit events resulting in increased sales revenue of 200 million Baht (4,000,000 Euro) after the maintenance and inspection plans are implemented. Therefore, a long term plan should be established to sustain good power quality to the industrial estate.