International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Predictive Maintenance of the Transmission Overhead Lines to maintain the Reliability of the Overhead Transmission Lines Network: A Utility Experience

Renato Orlina Padilla[1], Ashraf Abdulsalam Albawaleez[2], Shaikha Abdalla Al Marzooqi[3], Mohamed Mohamed Gharib[4], Ahmad Mohammed Hassan AlRedha[5]

Transmission Maintenance Department-Lines Maintenance, Dubai Electricity and Water Authority

Abstract: ***This paper is a discussion on the brief description, experiences and key recommendations on the predictive maintenance activities implemented in the overhead transmission lines network of Dubai Electricity and Water Authority (DEWA), in Dubai in the United Arab Emirates, which significantly contributed in maintaining high reliability of the overhead line network. The core of the discussions was based from the experiences in implementation and on the results delivered which were found effective since abnormalities were anticipated allowing repairing to be done in a planned arrangement avoiding the occurrence of a forced outage event.***

Keywords: Overhead, Transmission Lines, Infrared, Thermal Imaging, Ultraviolet, Corona

1. Introduction

Overhead power transmission network is a key component of utilities' electricity network that links electricity power generating plants with the transmission level substations and for this reason, ensuring the reliability of this network is a prime objective of power utilities. In case a transmission line is suddenly cut off due to failure of its components, it will weaken the flexibility and stability of the network or even, it might decrease the overall reliability of the transmission network.

Failures of the components in the overhead power transmission line can occur due to several reasons such as aging, manufacturing defects or due to human installation errors. To be able to early detect components on the verge of failing, the implementation of predictive maintenance can anticipate failures before total breakdown occurs.

In DEWA, two (2) important predictive maintenance activities are being implemented to maintain the high reliability performance of the network's overhead power transmission lines which are as follows.

Predictive:
a) Thermal Imaging Camera inspection.
b) Ultraviolet Inspection.

The following are discussions on these activities, samples of the achieved results and the key points recommended based from experiences from implementation.

2. The Predictive maintenance activities implemented in the Transmission Overhead Lines (TOHL)

2.1 The Infrared Thermal Imaging Camera Inspection

Infrared Thermal Imaging camera inspection is a non-invasive condition monitoring inspection carried out in overhead line maintenance to inspect the joints in the terminal ends and tension towers with the use of IR Thermal Camera technology. This inspection is done on a yearly cycle on all energized joints to check for any signs of overheating. In case a joint overheats and reached critical levels, the conduct or may be cut causing forced interruption, unbalanced load, or a disconnected jumper may swing and hit the tower body causing a line to ground fault. The camera in use is handheld which can accurately measure the temperatures on the joints including detecting where the temperature is the highest. Shown below in Figure 1, is the site staff implementing thermal imaging using handheld infrared camera, while Figure 2, shows an example of an overheating abnormalities detected, and the in thermal images generated are shown.

Figure 1: Example of Infrared site inspection using infrared handheld camera
(Source: DEWA site reports, 2012)

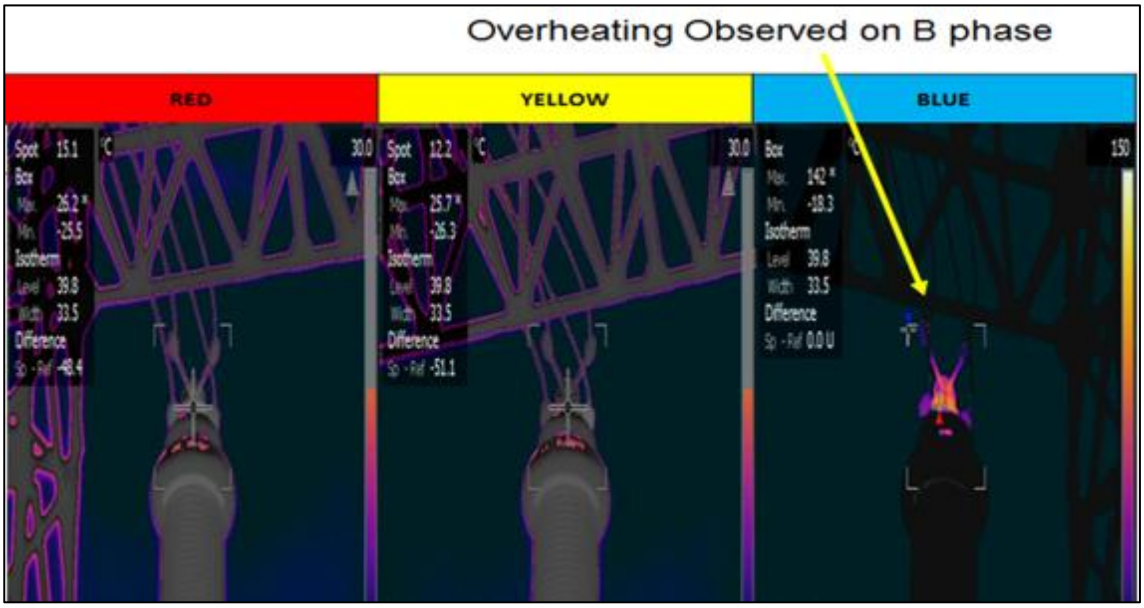

Figure 2: Examples of the overheating abnormalities detected, and thermal images generated (Source: DEWA infrared inspection site reports, 2012)

The criticality level of overheating is determined based on the Delta T Criteria: The Delta T criteria is defined as the levels of ranges of temperature rise of the exception (T1) above the temperature of a defined reference of the ambient temperature or a similar component (T2) under the same conditions. Delta-T temperature difference between T1 & T2, is calculated to determine the temperature severity of the case according to the EPRI Infrared Thermography Guide, Revision 2 (NP-6973s-Rev.2) [1]. In the following table 1, is an illustration of the severity level ranges as per the calculated Delta-T temperature difference with the corresponding recommended action based on EPRI (NP-6973s-Rev.2).

Table 1: Delta – T Severity Levels as per EPRI Infrared Thermography Guide.
(Adopted from DEWA overhead power transmission lines infrared inspection quality procedure based on EPRI NP-6973s-Rev.2)

Priority	Priority Level	Delta T (^{0}C)	Recommended action
4	Advisory	0.5 to 8	Failure unlikely, to be inspected again
3	Intermediate	8 to 28	Probable deficiency, follow up every week or month
2	Serious	29 to 56	Certain Deficiency, corrective action required
1	Critical	56 above	Major defect, repair immediately

2.1.1 Sample cause of the overheating

Overheating on joints may be caused by overloading of the conductor or loosening of connection on the clamp or compression joint. However as experienced, all were related to loosening on the connection joints. In all cases where the overheating was rectified, the contact resistance is found high and way beyond the allowable contact resistance (based from standard value) as measured using a contact resistance meter. The causes of the high contact resistance found during rectification are loosened machine bolts (in few cases undersized machine bolts), loosened compression joints and intrusion of contaminants in between the terminal plates as shown below in Figure 3.

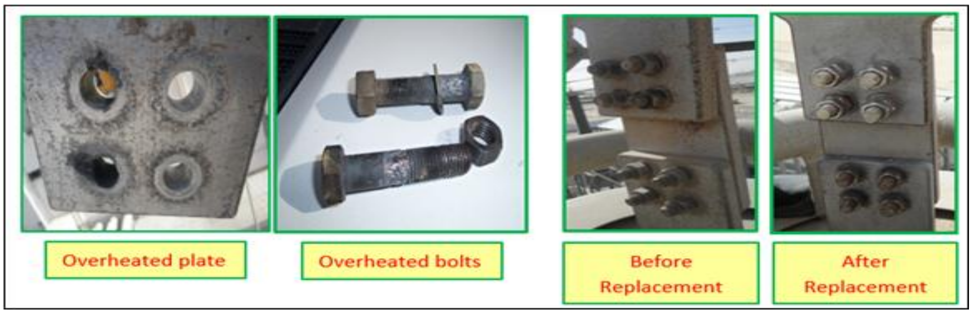

Figure 3: Overheating due torusted and undersized bolts.
(Source: DEWA corrective maintenance site work reports, 2012)

During rectification, the terminal plates were opened and thoroughly cleaned with the use of appropriate tools needed in compliance with the methodology established for the repairing of overheating. In some cases, the compression joints are retightened using hydraulic pressing machine with appropriate size of die. To check if the repairing work is done properly, the contact resistances of the points are again re-checked with the use of contact resistance meter.

2.1.2 Infrared (IR) thermography key points

The key points to be considered in implementing the IR Thermal camera inspection are as follows;

- Ensure the camera is with Field of View (FOV), IR resolution and zooming capacity that can reach the distance and see in clear view the points in the towers the targeted components.
- To use appropriately specified contact resistance meter (correct micro-ohm/meter range) & to measure the contact resistance of the points rectified before and after the rectification.
- To use the appropriately sized torque wrench and die (of the hydraulic machine).
- To conduct verification scanning after rectification once the line is re-energized.

2.2 The Ultraviolet (UV) Camera Inspection

UV Camera inspection is also a non-invasive inspection of the energized components of the transmission overhead lines such as the insulators, fittings and conductors with the use of hand held UV corona camera that is technologically capable of detecting any discharges of corona even during daytime. Corona discharge is a luminous partial discharge on the conductors and insulators due to ionization of the surrounding air. This corona phenomena can cause arc burning and chemical reactions that produce Ozone and Nitric Acid. If high levels of corona discharge are left undetected and continuously occur, the components exposed with it can be damaged.

During routine inspections, DEWA site inspectors found that normal energized lines indicate readings of minor level of photon count from the UV camera. However, if the photon UV count becomes high on a local part inspected and together with it a concentrated corona is observed on the camera monitor screen, it indicates that an abnormality on the identified location may exist and will require a more intensive inspection to verify any presence of defect. The maintenance priority rating is based on the Site Inspection Guide, issue: 1.0 – September 2013 which adopts EPRI's Field Guide' Daytime Discharge Inspection of Transmission and Distribution Overhead Lines and Substations-Technical Update Report 3002002844' [2] [3]as shown below in Table 2.

Table 2: Ultraviolet discharge severity levels
(Based on Site Inspection Guide, issue: 1.0, 2013)

Rating	Severity/Abnormality	Action
A	• Minor/Negligible discharge activity	No action required
B	• Discharge activity may be decreasing component life. • Discharge activity may result in audible noise (AN) or radio interference (RI) complaint	Monitor for further damage
C	• Damaged or degraded component • Damaged but will not affect short-term safety or reliability	Replace or repair at the next opportunity
D	Component poses a risk to either safety or reliability of the system in the short term	Remove from as soon as possible

2.2.1. A Sample of Corona Abnormality detected on the Underslung Insulator

Shown in Figure 4&5 respectively provide an example of UV corona abnormality observed on a 400kV underslung insulators. It can be seen from the picture the localized corona discharge with high corresponding photon readings found on all the 3 phases R, Y& B.

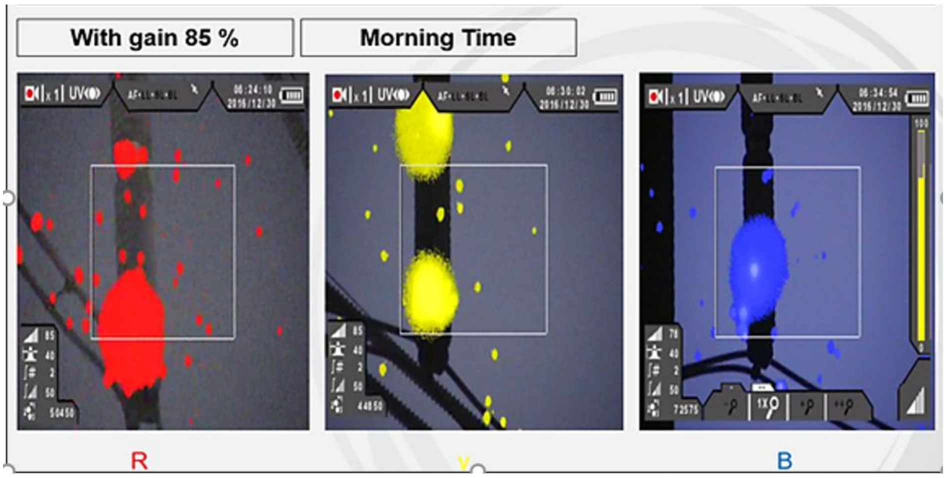

Figure 4: Sample of Ultraviolet Corona discharge abnormality
(Source: DEWA ultraviolet inspection site reports, 2016)

Figure 5: Defects (traces of black spots) found on the under slung insulator silicone coating. (Source: DEWA ultraviolet inspection site reports, 2016)

After detecting the abnormality, it was verified through binocular inspection traces of black spots on the insulators. Based on these findings, a close-up inspection on the insulators were conducted during a planned outage of the 400kV circuit and it verified the existence of burnt marks and deterioration of the silicone coating on the local areas where the corona discharges were found. Based on this confirmation, silicone coating has been re-applied and the corona readings from the later UV camera inspections found normal.

2.2.2. Ultraviolet scanning key points

The key points in implementing the UV Corona camera inspection are as follows.

- Use a UV camera with the appropriate UV sensitivity. It is able to record and display the value and severity of the detected corona.
- Use a camera the appropriate UV and Visual resolution which can reach the target points on the transmission lines. It can switch between the fields of view in both the UV and visible channels resulting to having powerful zoom.
- In case an abnormal corona reading is detected, the subsequent investigation of the source of corona should be done through close inspection, preferably during a planned outage.

2.3 Proposed IR and UV Reliability Centered Maintenance (RCM) predictive inspections basic process flowchart

It is of high importance that predictive maintenance activities to be planned and implemented in accordance with an established and well controlled RCM plan to insure proper implementation and results. As per our experience, the implementation of the IR and UV RCM predictive inspections in accordance with RCM plan will insure to correctly process and monitor implementation as per the required cycle.

However, proper implementation of RCM predictive inspections requires them to be managed through a maintenance and asset management information system. The aim of this system is to guarantee that inspections are done as planned, with resources and outages being well coordinated, and recording any abnormalities detected quickly on the information management system: updating, close monitoring, and setting a date for a planned outage to rectify the matter. For this purpose, we propose the following RCM predictive inspection basic process flow chart as shown in Figure 6.

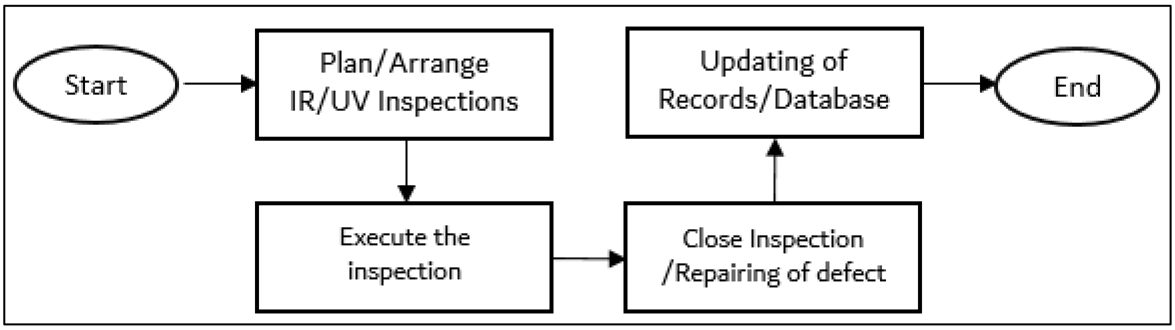

Figure 6: Basic Flow Chart of Maintenance Information System
(Source: Authors, 2021)

3. Conclusion

Our experiences in DEWA implementing the latest technology overhead power transmission network predictive maintenance shows that proactive non-invasive inspections using IR and UV cameras result in early detection of defects, which in turn eliminated forced outages caused by overheating or corona-related failures. We recommend that power utilities include these predictive methods in their maintenance programmes.

References

[1] EPRI, “Infrared thermography field application guide, ” California, 1999. [Online]. Available: http: //scholar. google. com/scholar?hl=en&btnG=Search&q=intitle: Infrared+Thermography+Field+Application+Guide#1.
[2] UViRCO, “CoroCam Users Advanced Site Inspection Guide, issue: 1.0, ” 2013.
[3] EPRI, “Field Guide: Daytime Discharge Inspection of Transmission and Distribution Overhead Lines and Substations, ” California, 2013.
[4] IEEE Power Engineering Society, *IEEE 957-2005-IEEE Guide for Cleaning Insulators*, vol.2005, no. September.2005.