# REDUCING OPERATION COSTS AND LOSSES USING THERMOGRAPHY

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## *ABSTRACT*

*Operating distribution networks in southern region of Iran located in northern coasts of Persian Gulf and Oman Sea requires special conditions. Environmental conditions like high temperature and humidity, Sunlight severity, very low raining, Obstacles in the air in addition with conditions like high energy consumption per capital, fast growth of energy demand because of new air conditioning systems and immigration of people to this region and converting this region to the largest industrial zone of Iran, all caused a very fast age reduction in distribution networks installed, so that the rate of aging has been estimated up to 40%.*

*Considering above mentioned conditions and our experts' high load of work for operating and maintaining the old installations in addition with their efforts for avoiding the black-outs, Objectives of the Hormozgan Electric Power Distribution Co for reducing the black-outs caused rescheduling old preventive maintenance plans.*

*This paper is a review of Hormozgan Electric Power Distribution Company's experiences using thermographs for preventive maintenance and inspection in Hormozgan region. In this project, 151 middle voltage feeders in 5,700 Km grid were inspected and 2,200 lose connections were discovered. Fixing these loose connections resulted reducing 10.5 MW power losses and reduce the costs of operation up to 39 million USD during the year 2009.*

## INTRODUCTION

Hormozgan province is the nearest region to the equator in Iran. The weather is normally hot, dry in coasts and humid in flats. Hot summers and average winters are usual weather conditions of this region. Humidity is between 19% min and 100% max. Geographical conditions (low longitude and latitude and locating near sea) cause very hot and humid weather conditions which is the most annoying weather conditions in the world.

These criteria cause severe faults in operation and providing continuous energy to the civilians. Since operation needs daily repairs, tracking anomalies and preventive actions for avoiding component failures and enforced black-outs, operating personnel would be exhausted very soon, so that the useful working age of our human resources is reduced up to 15 years at most.

Figure 1 shows the black-outs for enforced maintenance (EM) in 2006, categorized by the type of faults.

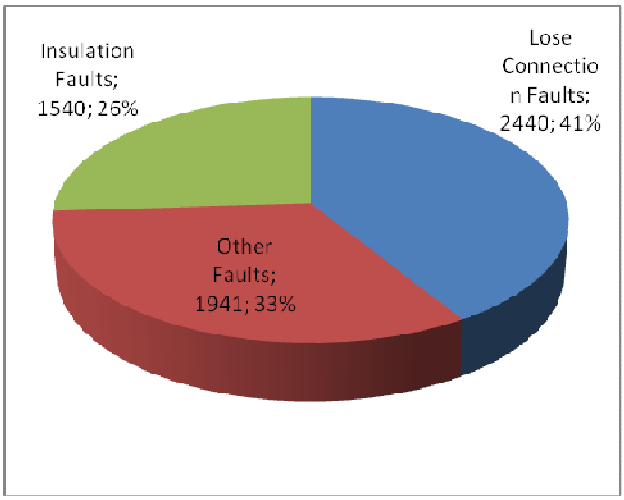


Figure 1: Enforced Black-outs categorized by the reason

The most EM black-outs are for fixing lose connection, mainly because of thermal faults in our distribution network, including insulator flashover due to salt pollution, corrosion on equipments and the connections resulting leakage current and related losses.

Following three pictures show some lose connections that cause losses and black-outs for enforced maintenance in the distribution network.


Figures 2-4: Lose connections resulting enforced black-outs and power loss

Because of lose connections in year 2006, the loss factor was 21.83 % and the spent costs of enforced maintenance reached to around 5 million USD.

## DEMAND OF USING NEW TECHNOLOGIES FOR MAINTAINING THE ASSESTS

Due to inefficiency of old methods of asset management, the necessity of strategic planning based on modern and up-to-date technologies realized by utility company managers. In 2001, decision makers of Hormozgan Electric Power Distribution Co decided to focus on reducing the problems of permanent service provision to clients; therefore they started funding on modern and new technologies and updated their engineering knowledge based on a strategic plan with short and long term objectives as follows:

- Improve the insulation resistance, by changing porcelain to silicon insulators
- Reducing the effects of corrosion in aluminum & metal by installing bimetal connectors such as fixings and clamps
- Reducing the effects of pollution in insulation equipments by changing isolation of surge arrester, cut-outs and bushings from porcelain to silicon
- Indoor insulator coating by silicone rubber materials for higher insulation resistance
- Porcelain bushing coating for transformers and insulator replacement by silicone rubber
- Indoor distribution substation replacing with compact type for corrosion effects reduction.
- Over head Gas type disconnector installation for over head reliability.
- Distribution Network Automation and remote operation

Performing above mentioned acts and using modern technology caused reducing black-outs from 8 minutes per client in 2001 to 3.28 minutes in 2006. Continuing the strategic plan focusing on reducing the black-out rate to 2.5 minutes per client in 2008 resulted the traditional outlook on planning changes to preventive maintenance in the middle of 2007.

## PLANNING PREVENTIVE MAINTENANCE USING MODERN TECHNOLOGIES

Performing different methods for industrial maintenance and repair based on predictive maintenance has a history for 50 years. Fundamentals of all these methods are based on two bases, “upgrade the level of maintaining repairs” and “prevent before equipments’ defeats and problems”. In the other hand, continuing and repeating the inspections, monitoring the equipments’ status and specifying the service and replace schedule have already proved their important roles in these methods.

Electric Current in circuits and equipments is always with heat and temperature increase. Centers of heat in equipments are mainly because of not fixing connectors, oxidize and corrosion. Asymmetric Phasy and problems in insulators of rotors in addition with direct sunlight are also the major reasons of defeats and problems in equipments. To perform the advanced service and inspection in accordance with the circumstances, Thermography devices were purchased and appropriate training courses were held in current year.

The first workshop of preventive maintenance was held in September 2007. After training the operators and managers, specifying a pure model for preventive maintenance and repair was a high demand. In this stage, CMMS courses were organized and the pure model for maintenance and repair of CBM was set up, including transformer oil’s analysis in whole region and thermo vision of distribution grid for detecting lose connections.

This method would be described in the following.

## REVIEWING THERMOGRAPHY RESULTS IN DISTRIBUTION NETWORKS

One of the advanced methods of condition monitoring and predict the faults in equipments is to use the Thermography. In this method, thermographs of distribution lines, transformers, switches, fuses, cables, metal connectors, boards and other elements would be obtained and by measuring the temperature of these elements, weakness and faults would be determined. Based on a specific schedule in which the priorities are clearly stated, the problems would be fixed before causing faults or black-outs. In this method the thermal energy which is emitted from the equipments, would be revealed, then by considering the standards, priority of repairs would be determined and specified.

In table 1 next page, faults' categories based on NETA standard (National Electrical Tests of America) are mentioned.

| Thermal Difference With : | | Element Condition considering Fault Priority | How to repair the element: TO BE … |
|---|---|---|---|
| Surrounded Area | Same Element | | |
| 1 - 10 °c | 1 - 3 °c | 1 : Probable Fault | monitored & controlled |
| 11 - 20 °c | 4 - 15 °c | 2 : basic levels | scheduled for repair |
| 21 - 40 °c | > 15 °c | 3 : advanced level | repaired ASAP |
| > 40 °c | > 15 °c | 4 : Serious Fault | repaired urgently |

Table 1: IR Scanning Category for Thermography

Considering above mentioned table and the results of recurrent thermo vision schedule, table 2 would be achieved.

| Condition of Work | Thermography Interval |
|---|---|
| Critical | 3 Months |
| Urgent & Important | 6 Months |
| not Urgent, not Important | 12 Months |
| Follow-up prior services | 3 Months |

Table 2: Operational grading of lose connection based on experiments in Hormozgan Network

Using Thermography in summer 2007, thermo vision results of 40 distribution feeders in the center of Bandar Abbas were considered. Evaluating the costs of repairs and maintaining mentioned faults in these feeders in a pilot project and comparing the reduced costs of essential and critical repairs with the costs of Thermography, following information achieved in table 3.

| Description | Spare Parts & Salary Costs (US$) |
|---|---|
| Using Thermography | 43,350 |
| NOT Using Thermography | 441,890 |
| Reduced Cost | 398,540 |

Table 3: Comparing Operation Costs

Reviewing above mentioned table, it is clear that how much the preventive maintenance & repairs based on advanced technologies, could reduce the operation cost. Beyond that, the ratio of saved costs of enforced faults and not allowing the faults to higher levels, reaches to 90%. In the other hand following table shows the price of un-distributed energy because of fault detection and enforced black-outs, in comparison with the distributed energy when PM using Thermography was used.

In 2008 this method confirmed as an executive procedure, by purchasing 12 sets of Infrared Thermography devices and set up equipped teams for inspecting the distribution network in Hormozgan region.

## EVALUATING THE RESULTS OF MONITORING THE CONDITION OF FEEDERS

Statistics of reducing black-outs caused by sudden faults of lose connections are shown in figure 5.

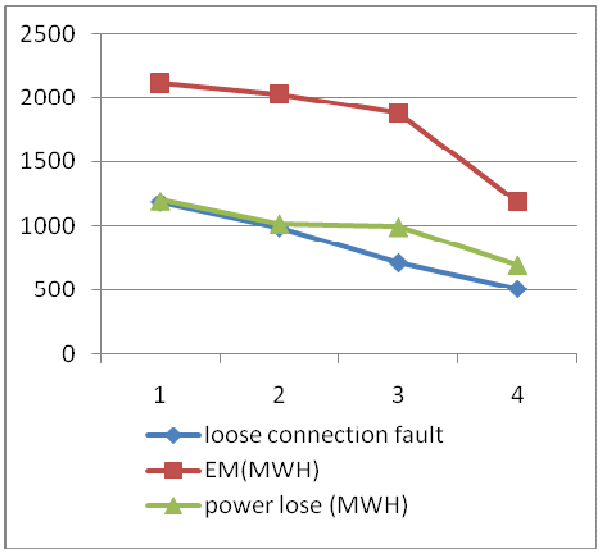


Figure 5: Reduction of scheduled black-outs for operation

As it is clear, black-outs reduced from 2440 to 509 during the years 2007 to 2010, which is around 80% lower.

Also the amount of un-distributed energy in sudden faults, shows 59% decrease and the amount of energy loss in MWH shows around 54% decrease in the year 2010. (Figure 6)

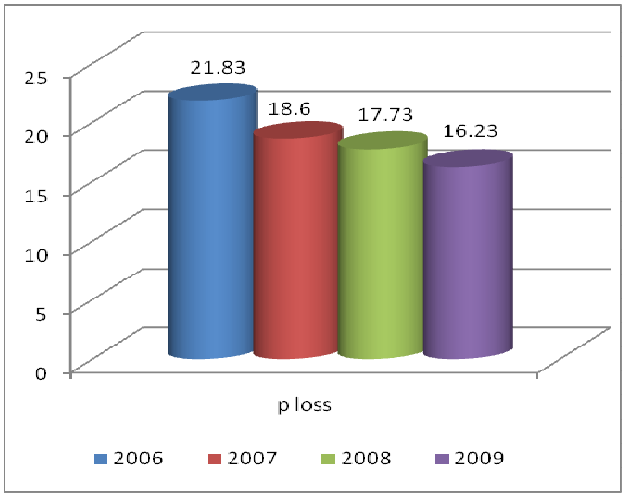


Figure 6: Reduction of power loss in each year

As shown above, after detecting loose connections by Thermography and after repairing them, more than 5.6 % loss reduction achieved on 200 feeders (half of the total feeders in Hormozagan region).

Retrieved cost of this loss reduction was 28,000 USD.

Following is the table 4, showing the reduced the number of lose connections and the reduced loss in each year.

| Year | Feeders | Length (Km) | Loose Number | MW |
|---|---|---|---|---|
| 2007 | 40 | 1500 | 1062 | 2.5 |
| 2008 | 66 | 3515 | 2840 | 7.5 |
| 2009 | 109 | 3489 | 1789 | 9 |
| 2010 | 151 | 5700 | 2200 | 10.5 |

Table 4: Loss reduction and number of lose connections in each year after thermography PM

## CONCLUSION

Thermography as a tool for monitoring the condition of distribution networks in special environments like the salty coasts played a very important role in reducing the operation costs.

Hormozgan Electric Power Distribution Co fully realized the benefits of an effective Condition based Monitoring program based on IR scanning, simply because we could manage having the knowledge and resources to do so. The experiences of operation in such Hormozgan region for many years, show that how important is avoiding sudden faults by preventive maintenance.

Reducing the operation costs and scheduled black-outs instead of sudden faults are other advantages of using this technique.

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