CIGRÉ Regional South-East European Conference
October 10th - 12th 2012
Hotel Hilton, Sibiu, Romania
(RSEEC 2012)

Proceedings of

RSEEC 2012

Innovation for future!

Section E

Organized by:

Romanian National Committee "CIGRÉ"
33, Gen. Gh. Magheru Blvd., postal code RO-010325, Bucharest 1
Registration no. with the National Trade Register - 173/2007 – fiscal code: 20769417
Phone: +4 021 31 72 160; Fax: +4 021 31 72 300; www.cigre-cnr.ro
Mailling adress: 2-4 Olteni street, postal code RO-030786, Bucharest, Romania

Descrierea CIP a Bibliotecii Naţionale a României

ISBN 978-606-8371-74-0

Published by: The Academy of Romanian Scientists Publishing House
54 Splaiul Independentei, District 5th, code 050094, Bucharest, Romania

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TABLE OF CONTENTS

SECTION E. Live Working

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E 101

Maintenance with Live Working Technology by the TPG Administrator

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SUMMARY

Reducing losses in Transmission Power Grid (TPG) can be achieved by applying the maintenance with Live Working (LW) technologies. These LW technologies can be applied both to OHTL and substations. Also for all types of maintenance may apply LW technologies. The minor maintenance includes checks, inspections and small repairs or replacement of worn pieces. Major maintenance include repairs to all or large parts of defective parts or which may fail in the near future, replacing all worn pieces or partially (over 50%), replacement pieces, which are no longer appropriate current technology, with new pieces, with greater efficiency, modernization of equipment. Application for all or part of maintenance of the LW technologies can lead to significant decreases in operating and maintenance costs for projects of the beneficiary.

Organizing of the maintenance with Live Working technology can be achieved only with the involvement of both parties equally: the service company and the beneficiary company. Some measures have taken by the power grid administrator for execution of these works. To work with these LW technologies, work organization in terms of project beneficiary, is achieved by programming soon as possible of these works, taking into account several technical criteria and climate, their correlation with other works, with conventional technologies, updating constantly project status, permissions for works by request and reception. So, the organizational complexity increase, and this will includes the need to increase the efficiency of project management side, in terms put by the beneficiary.

To support decisions on the execution of works with LW technology can be used multiple sources, such as monitoring systems, and other methods of surveillance and control and information systems. Execution of works with LW technologies can be achieved only if at the work place exist the climatic and technical conditions. Climatic conditions can be obtained through measurement devices or portable or through monitoring systems those OHTL parameters. Technical conditions are given according to applied technology and the preparation of the works by the personal, in this respect. To make better decisions, knowing the climatic parameters and operating parameters OHTL, can be use computer programs and graphs obtained from these, which is necessary to get the preparation of works.

This paper presents the use of information systems and monitoring systems in decisions for applying the maintenance with LW technology, a comparator between the efficiency of maintenance with technologies for OHTL in service and with LW technologies and an analysis on both activities Remote Command and Surveillance of Substations and maintenance with Live Working technologies.

KEYWORDS

Live Working, Overhead Transmission Line, Efficiency, Maintenance

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1. ORGANISATION OF WORKS

To achieve the works with these LW technologies, the participants to project are required to take organizational measures. These measures are taken both by the project beneficiary and the executor.

In this context, stage by stage, the project owner is more or less involved in organizing this works. In terms of organization of project, the works with conventional technologies involve programming in advance of the work by the beneficiary, permissions for works by request and reception. To work with LW technology, work organization by the project beneficiary, is achieved by programming the work, taking into account a number of technical criteria and climate, the link this work with conventional technologies, updating permanent the project status, permissions for works by request and reception. So, this will increase the complexity of the organization and includes the need to increase the efficiency of project management site in terms of beneficiary.

Such projects require a more efficient organization of the beneficiary by the project team and technical advisory team (Projects Management Office), which lead to changes in the organization. In this context the organization should adopt a modern management structure by projects type, advanced, or mixed, both structure by project and functional structure.

Following information received from the field by making the controls, inspection related to minor maintenance, and from the monitoring systems and from the surveillance equipment, can be obtained the defective or worn parts and their behaviour over time.

Can be performed the analysis for the operating behavior of equipments and can be taking measures to improve the efficiency of operation and maintenance scheduling [1]. Based on this information and depending on the technology hold by the executants unit, should be scheduled maintenance works LW technologies.

Besides the information mentioned above, for works with LW technologies, are needed and information on environment and information on the NPG condition in the area.

Executants Unit will inform from the beneficiary unit, with respect to works that will be executed, about the operating behavior of parts and weather information.

2. EFFICIENCY OF WORKS WITH LW TECHNOLOGY

Not only small-scale works that are carried out in minor maintenance with LW technology can bring the benefits to the company, but also large-scale works in major maintenance. The more so, if the major maintenance with classic technology which extend time much longer, the benefits to the company, of the project owner, will increase by applying the LW technologies. Thus, the works on short-term and with low cost in technologies with withdrawal from service of equipment, in minor maintenance, were less profitable if were made in small quantities. Furthermore, even by application of technology LW, in that case, was not more profitable. Instead, to the major maintenance, by increasing the number of such operations, this works have become profitable for both the performer and the recipient.

During major maintenance for OHTL 220kV Stejaru - Gheorgheni, OHTL 400kV Mintia - Sibiu Sud, OHTL 400kV Urecheşti - Rovinari G3+4, OHTL 400kV Urecheşti - Rovinari G5+6, OHTL 400kV Ţânţăreni - Turceni G1-2+G3-4 and OHTL 400kV Ţânţăreni - Turceni G5-6+G7-8 [1-4], both technologies were applied, with the withdrawal of service of OHTL and with LW technologies. Given the importance of these OHTL in the NPG was sought, according to LW technologies available in our country, the operations with LW technologies to be as many.

Operations performed on OHTL with these LW technologies were:

- Installation of air marker plates on tower tops
- Adjustment the position or replacement of dampers on the active conductors
- Replacing the spacers
- Replacement the elements from composition of chains of insulators (nuts, suspension clamp, etc.)
- Replacement of corona rings at the suspension towers
- Replacement of broken glass insulators from chain of insulators
- Replacement of suspension clamps of the active conductors
- Preparation work and painting of corroded elements to canopy of towers
- Replacing the tower's anchors

If any equipment is withdrawn, we have the following costs:

- Actual cost of works
- The cost of active power losses due to changes TPG configuration and increase the power transmitted by other OHTL
- Cost of congestion

By applying those LW technology for OHTLs mentioned above, compared with classical technologies, with withdrawals of these equipments, was achieved the economic efficiency shown below in table I:

Table I: Efficiency by operations of LW technology applying to Major Maintenance of OHTL

Operation	Efficiency
Replacing the glass insulator / 1 tower	20%
Replacing the clamps	15%
Replacing the anchors	8%
Overall	Efficiency
Total operations on OHTL 400kV Mintia - Sibiu Sud	7%
Total operations on OHTL 400kV Ţânţăreni - Turceni G1-2+3-4	9%
Total operations on OHTL 400kV Ţânţăreni - Turceni G5-6+7-8	9%
Total operations on OHTL 400kV Urecheşti - Rovinari G3+4	8%
Total operations on OHTL 400kV Urecheşti - Rovinari G5+6	8%
Total operations on OHTL 220kV Stejaru - Gheorgheni	2%

Methods for growing up to high voltage applied to works with LW technologies, mentioned above, were: method of ergonomic seat, method of insulated ladder from the console, method of insulated ladder from ground, method of truck with platform lift and insulated arm.

A sample calculation of efficiency is presented in the table below (table II), for major maintenance works on OHTL 400kV.

Table II: Efficiency of Major Maintenance first stage operations with LW technology applying to an OHTL 400kV

Classic Technology		LW Technology	
Time for OHTL operations [h]	553	-	
Energy price [lei]	260,4		
Power losses TPG [MWh]	2,5		
Power losses costs [lei]	360003		
Operations costs [lei]	532000	Operations costs [lei]	845000
TOTAL cost for CT [lei]	892005,5	TOTAL cost for LWT [lei]	845000
EFFICIENCY:	-	47005,5 [lei]	5,5%

3. TRAINING CENTRE FOR LW HUMAN OPERATOR

Applying live working technologies under maintenance involves to training the human operators. The efficiency of the maintenance in this case will increase with 25%.

To prepare the human operators in order to authorize them to live work and approval of the applicable LW technologies in TPG, NPG “Transelectrica”-JSC has established the “Center for Research and Development Live Works Technology and Immediately Response in National Power System" - CRDLWTIRNPS (hereinafter will use the term LW Center).

LW Centre provides training of human operators by:

- Courses Specialized training: human operators for overhead lines and stations with classical technologies, human operators for overhead lines and stations with LW technology, operational staff from stations, operational staff from Remote Center and Dispatching Center;
- Training and testing in LW polygons: LW polygon for overhead high voltage, LW polygon for MV and LV overhead lines, LW polygon 110-400kV stations, LW polygon for MV and LV stations;

- Specialized laboratory tests for LW, electrical measurements, etc.
- Technical advice and logistical support for multispectral inspection and diagnosis;
- Certificates & approvals for LW technologies

A training facility offers advanced and comprehensive risk assessment without time pressure, and perhaps inexperienced employees to ensure proper learning of limiting or eliminating them. Awareness of the risks present at work during the hours of practice, allows the employee to fully participate in the training process, which results in a high efficiency of the training.

The role of a training base is not limited to LW theoretical courses, also it's can be used to train the workers and equipments for experimentation and new technologies. It can thus establish collaborations with manufacturers, who can test their prototypes in such a training facility.

The centre also provides training for staff operating in the stations, in Remote Control Centers and in Dispatching Centers, by simulator exercises. Also within the training centre can be made for testing, licensing, and renewing their staff from Distribution System DS and Transmission System TS and Power Plants PP.

In this Center the training course will make in two parts. The first part of a training course is theoretical. This will be achieved through high-level teaching materials in specially equipped classrooms. We will present the concepts and theories on LW, details of working technologies, risks and safety measures and health, etc.

The second part of the course will consist of practical training at LW polygons. In figure 1 is present the polygons of 220-400kV and 110kV overhead lines.

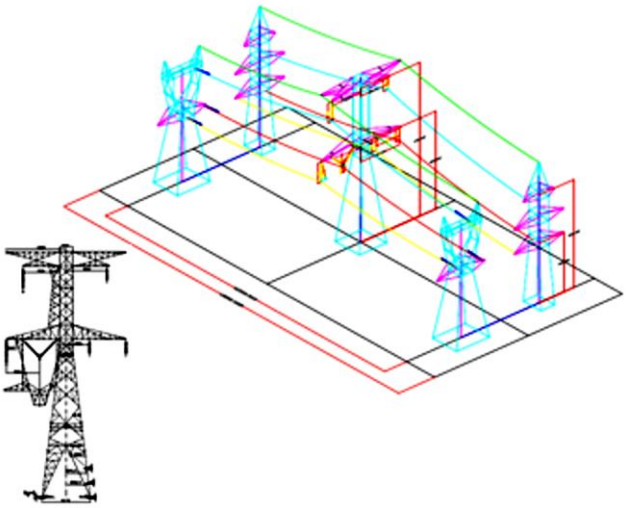

Figure 1. Training Polygon for OHTL 220-400kV

The human operator will be prepared to live works depending on the technology, installation tension and the risk factors to which it is subjected. Also adequate preparations for the performance of LW human operators lead to the execution of quality work and safety conditions at a better management of maintenance activity.

4. LW TECHNOLOGIES AND IMPLICATIONS IN OPERATIVE ACTIVITIES

To applying LW technologies in equipment maintenance, from the operational point of view, does not generally perform maneuvers. In some cases, in terms of occupational health and safety, it requires that equipment on which maintenance is applied LW technologies, to be bringing in a special operating configuration.

In the first case the operative implication of maintenance with LW technologies does not exist, the status of the equipment is based on the same terms that were before the work starts. This requires only notifying the decision-makers of TPG operator, on operative way, that this equipment is in maintenance.

In case of bringing in special operating configuration this equipment, for the maintenance, the involvement in the operative functioning implies that the equipment should operate without automation.

Cancellation the automations lead to measures involving the decisions of the power system reconfiguration in case to loss of this equipment (breaking of) tacked by the TPG operator.

None of the cases, presented above, not involves the reducing the power transmitted through the equipments.

These activities do not involve performing complex operations for the work with LW technologies. Such maneuvers can be performed entirely by remote control from a control center or RCSC or a dispatch center with direct control over those installations.

Informing operational staff and operational management staff about special technologies (including LW technologies) is done in the training courses for staff, in the Company, to Centre of Excellence - Centre for Research and Development of Live Working Technologies and Emergency Intervention in the National Power Grid. The course shows the aspects regarding the conduct of operational activities and activities for operation of equipments, in general, for works with LW technologies and concepts on the application of these technologies in the NPG, in special way.

On the other way, the preparations for operations with LW technologies can be base on date from monitoring systems and multispectral inspections (IR spectrum, UV spectrum, etc.).

The data from monitoring systems can be achieved (on-line or off-line, historical data for an equipment) from the operators of Remote Command and Surveillance Centers. In this case the monitoring system must meet several requirements:

- Transmission will not scrambled or jam of/to other systems or active parts
- Preliminary analysis of input data (filtering / sorting values unlikely for the visualization and technical analysis, but not for the rescue / storage - and identifying them)
- Reliability analysis of data for specified periods - daily, monthly, annually
- Graphical analysis of data for periods predefined by the user (for the whole period of follow-up)
- Friendly representation of data in graphic form, tabular and text, and an easily accessible menu
- Warnings and blocking status from software
- Access to safe levels of importance
- Secure views from multiple external channels
- Anti-phishing
- Main Display with contain all completely visible signs graphics arranged in order of importance, the text signals visible part - last 3 active color with respect to color code representation (IEC)
- Second Display (without sub screen) dedicated to each piece of equipment
- To provide auxiliary programs for capture and export of data, communication, display / playback
- Arranging graphics on the screen will be on themes (sets of parameters grouped by type and monitoring equipment)
- Will respect the standards color code for alarm signals, voltage levels, etc.
- Onscreen colors are warm and high contrast to background (increased visibility)
- Consultation screens will contain all parameters monitored equipment
- Alarm lists will contain all active alarms and alarm history all with their status
- Technical data files contain all the parameter values of a parameter within a given time (day, month, and year), all parameter values (including graphics displayed on the screen)
- Data transmission will be achieved through transmission protocols IEC (60870-5-101 and / or IEC 104, 61850)
- The data processing must contain the elements of statistics and probability, neural networks and TIS

Also the data needed for the preparations of the operations with LW technologies can be obtain by using data from the study aimed to develop efficient methods of operation for the high voltage equipment. The new solution of analyses combine behavioral studies inspired architecture analysis equipment assigned to stations based on current mathematical methods, with the ultimate goal of streamlining the business into operating performance, aimed in essence, the strategic assessment of their expectations.

5. USING MONITORING SYSTEMS

Monitoring systems can provide information on the status and operational behaviour of equipments and their components.

The monitoring systems can makes the measurements of following parameters of the OHTL:

- The temperature of the active conductor
- The load on OHTL
- The temperature of air (ambiance)
- The wind speed

The communication between receiver and central unit of the monitoring systems is achieved by optical support, and the communication between central unit and user's server are routed by GPRS systems [6]. This allows communication with the monitoring system, including from place of the works with LW technologies. For this, the executants will need to have a laptop with GSM transmission card, the monitoring program and access agreement from the beneficiary unit.

The monitoring systems for equipment from substation can be found in the control room.

Figure 2 shows the graphics data from a monitoring system of 220 kV OHTL.

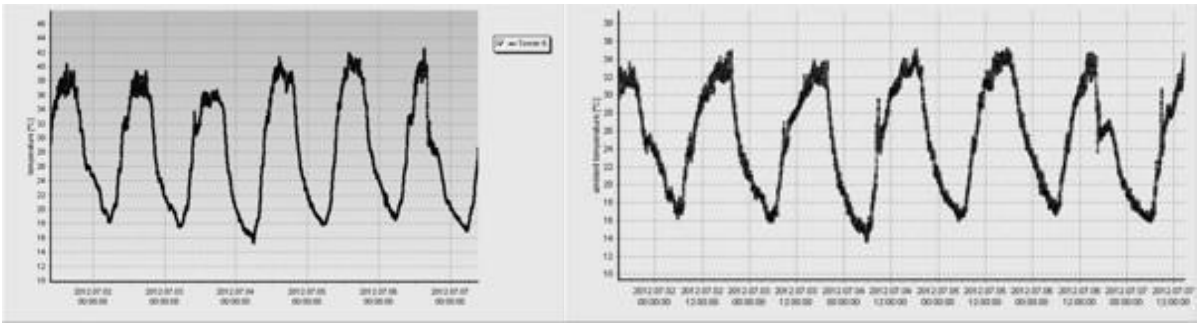

Figure 2. Ambient temperature (right) and active conductor temperature (left), on 220 kV OHTL, within 7 days

The data are used for making the best decisions to carry out works with LW technologies. To satisfy the conditions for making works with the technology LW is necessary to know the neighborhood distance for works.

Figure 3. Temperature monitoring system of active conductor, type RITHERM [2].

In figure 4 are neighborhood distances for works on the towers of OHTL 220kV, both conventional technologies, with the withdrawal of equipment, and live working technologies.