TRAINING OF HUMAN OPERATORS IN CENTRE FOR PERSONNEL TRAINING AND DEVELOPMENT OF NEW TECHNOLOGIES OF CNTEE "TRANSELECTRICA"-SA

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Abstract - Using new technologies to equipment maintenance have a number of advantages well known. By applying these technologies work will achieve significant increases economic efficiency only if applied properly. In this sense it must be adequately trained staff, both maintenance operators and operational operators.

CNTEE "Transelectrica" SA, through its policy, proposes the use of new technologies and LW technologies (live working). To develop and promote LW technologies and new technologies, the Company promoted the foundation of a centre for the training of personnel and development of new technologies. The centre will aim to promote new technologies and prepare personnel for the correct application of new technologies in our company and to increase readiness and effectiveness of actions taken by its own staff and authorize them for LW and other technology. Also the Centre can attest companies and their services and technologies.

This paper presents some aspects of the Centre and how personnel receive the training services for more effective implementation of these technologies.

Keywords: live working, training, technologies, maintenance.

1. INTRODUCTION

According NTE 010/11/00, human operators which operate in live working must be training in specialized centres. In this way CNTEE "Transelectrica"-SA has founding a training centre.

This centre provides training human operators by:

a) Specialized training courses for human operators in maintenance and operation OHL, human operators in operation and maintenance of substations, human operators in maintenance with new technologies and LW technologies at maintenance of OHL and substations, operational personnel of electric substations, personnel of remote centres and dispatch centres

b) Training and testing in polygons (electrical installations throughout the production, but identical in with those in operation) for the high voltage OHL, polygons for medium voltage or low voltage lines, polygon for 110-400kV substations, polygon for transformer post and distribution post

c) Tests and technical inspection in specialized laboratories for new technologies, LW, electrical measurements, etc.

d) Technical and logistical advice for multispectral inspection and diagnostics

e) Certifications and approvals for LST technologies

A basic training is an opportunity and comprehensive of risk assessment, without time pressure, for inexperienced employees and can ensure proper learning of technologies, discover the limitation or proper application of those. Awareness of the risks present in the workplace, during the hours of practice, allows the employee to participate fully in the training process, which results in high efficiency of training.

The role of base training is not only limited to courses in LW technologies, it can be used to train other workers and mainly for experimentation equipment and technologies. It can thus establish collaborations with other companies for equipment test and their prototypes in such basic training.

The centre also provides operational staff training for substations, remote control centres, dispatch centres, manoeuvrings simulator. Also the training centre can be made for testing, licensing and license renewal for personal from DPG, TPG and power plants.

In the field of energy measurement can be achieved exploiting instruction and training platform for the wholesale metering, local metering systems, the monitoring system of power quality education and training that will provide metrological activities in the field of electricity measurement, training staff will manage power quality.

2. HUMAN OPERATORS TRAINING

Training for human operators for LW technologies begins with recruitment, to meet work requirements in LW. Human operators must be licensed and professional, medical and psychological capable for this kind of work. Also its take into account the experience as lineman works with equipment retired from service. The selection of staff is made considering their technical skills, vocation for work of this nature, teamwork skills, skills on working at heights, working in hard environments and work in the presence of voltage.

A. The first part of the training courses is the theoretical. This is achieved by using high-level teaching material in specially equipped classrooms (Fig. 1). The course presents concepts and theories of LW technologies, details of working in technologies, risks and measures on health and safety at work, etc. Fig. 2 shows a type of technology that will be familiar to students.

Fig.1. The classroom for theoretical training at the Centre

Fig.2. LW technology using helicopter

In theoretical part we teach about:

a) Efficiency of technologies with examples of works was achieved

During major maintenance for OHTL 220kV and OHTL 400kV, both technologies were applied, with the withdrawal of service of OHTL and with LW technologies.

Table 1. Efficiency by operations of LW technology applying to Major Maintenance of OHTL

Overall works	Efficiency of total costs
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%

b) Safety in technologies operation

To satisfy the conditions for making works with the technology LW is necessary to know the clearance distance for works.

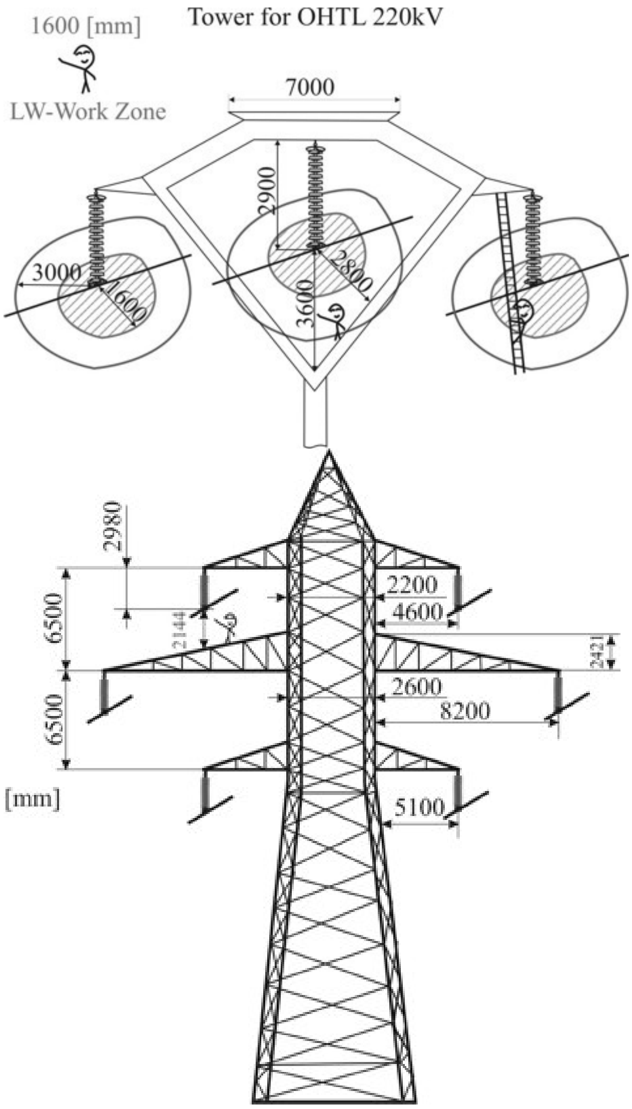


Fig.3. Clearance distances for works at 220kV OHTL

c) Using computer programs for simulation of work condition with new technologies (e.g. LW technologies)

The works with LW technologies can take place only if certain conditions are met. In order to prepare these works under optimal conditions, is necessary to know in detail how their conduct in certain circumstances. In this sense, we have achieved several theoretical and practical analyses. The theoretical analyses were performed using several software simulations.

To simulate the conditions at work in the context of unfavourable weather conditions were used the theory of distribution voltage on insulators chain through calculation of the equivalent capacitances [1-3].

The analytical method of calculation takes into account the longitudinal capacitance of the isolators, stray capacitance to ground and stray capacitance from conductor [1-3]. The general solution is:

$$U_x = \frac{U_0}{\left(C_{p0} + C_{v0}\right) * sh\left(\alpha_0 * l\right)} * \left\{C_{p0} * sh\left(\alpha_0 * x\right) + C_{v0} * \left[sh\left(\alpha_0 * l\right) - sh\left(\alpha_0 * (l - x)\right)\right]\right\} \quad (1)$$

where,
a_0 is the root of the characteristic equation for micro-distribution of capacitances,
l is the insulators chain length,
x is a point of infinitesimal area coordinated,
C_{p0} is stray capacity to ground,
C_{c0} is stray capacitance from conductor,
U_0 is voltage on the last element in the insulators chain [1]

This equation was solved by a program in MATLAB. The results are presented in Fig. 4.

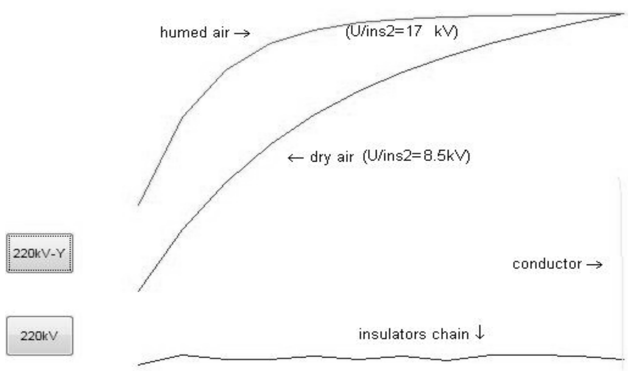


Fig.4. Voltage distribution in a chain of glass insulating type to a 220kV tower, "Y" type

d) Condition for technologies application

The efficiency of maintenance services depends on several factors like correctly applied technologies, costs and training human operators. The technologies used in maintenance are different.

Choosing a technology can be done according to several criteria, such as:
The parameters of electrical equipment;
• Operating costs of the equipment in terms of organizing maintenance services;
• Operational behaviour of the electrical equipment;
• Importance of this electrical equipment in electrical power grid / power system;
• Risks of applying the technology;
• Costs of the technologies;
• Efficiencies of the technology applied (in technical terms);
• Preparation of human operators and environmental conditions during execution

A preliminary decision may be taken and through the elastic characteristics of a system.

For the choice of technologies will take into account the following criteria:
• Operating Criterion, which envisages the condition of transmission power grid, respectively National Power System, for timeframes proposed
• Climate criterion that takes into account temperature, wind speed, humidity, etc.
• Technological criterion, which aims facilities with equipment and tools and their applicability to works in specifics electrical installations (gauge, power, access, etc.)
• Organization criterion, which relate to the availability, as well as equipment design, operating conditions, and so on,
• Technical criterion aimed module assembly - disassembly, shunt, etc.,
• Functional criterion refers to the proximity of other facilities, positioning, automation cancellation, and so on,
• Integrated management criterion refers to occupational health and safety, quality and environmental protection
• Criteria specific to particular technologies,
• The economic criterion

To calculate the reliability and elasticity of the architecture for system, we take in consideration the following factors:
• The safety of the scheme
• The architecture type of scheme
• The equipment's manoeuvres action
• The equipment's type and function
• The equipment's reliability
• The operational scheme
• The spare capacity of the scheme
• The operational mode of the equipment and the scheme (use, supervisor, manoeuvre, monitoring)

The statics elasticity coefficient of a system is:

$$E_S = N * \deg(N) * \frac{C}{I} * \prod_i \frac{I_{ri}}{I_{ti}} \qquad (2)$$

where:
N is number of nods from substations scheme,
C is number of all bays from substations scheme,
I is number of equipment connecting in substations (OHTL and Power Transformers Units),
K is coefficient depending by functionality of substations scheme – represent the percentage of equipment in function after an accidental event or a problem (I functional / I total, mean subscript notation r = remaining I after failure ant t = total I)
n is possible number of operating, [4, 5, 6]

The statics elasticity coefficient includes stationary characteristics of the system parameters only (structural characteristics).

The dynamic characteristics of the system are contained in the module of elasticity of a system.

$$E_D = f(P, \Delta p, C\&C, P\&A, OA) \qquad (3)$$

where:
P is transmitted power system,
Δp is system elements dynamic parameters (losses and others)
C&C is control and command behavior
P&A is protection and automation settings
OA is action of operators, [4, 5, 6]

The elasticity is:

$$E = \sum E_S * \sum E_D * W_S \qquad (4)$$

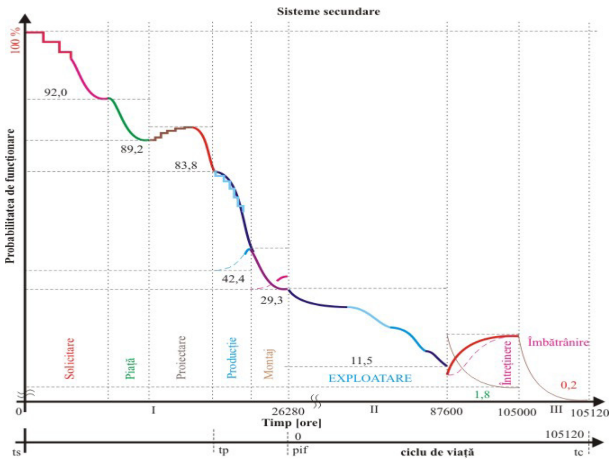
where:
E_S is statics elasticity coefficient (architectural type),
E_D is dynamic elasticity coefficient (functional type – depend indirectly of angle of voltage between two bus-

bars of substations – at ends, directly of graph / road and functional parameters),

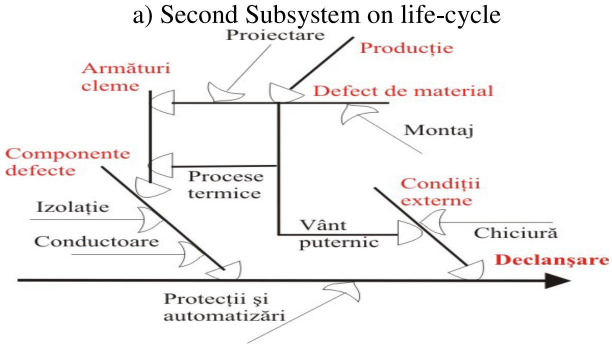
W_S is energy parameter of power grid (depend indirectly of real-time active power losses and reactive power losses – energy losses, directly of real-time transmission power, voltage and grid configuration parameter)

e) Analysis methods

Methods to analyze the equipment behavior or to find the solutions for an issue will be present for personnel.



a) Second Subsystem on life-cycle



b) Fault analysis

Fig.5. Analysis scheme [4, 6]

f) Simulations program

The training after theoretical knowledge but before practical task it's made on simulation program.

Analysis to operation of equipment and maneuvers modalities, as part of the operating activities, is achieved through a program which simulates electric networks. This program can configure the workstation for each type of substation architecture. It can also set the control station.

To calculate the simulated system schemes are needed to determine the electrical characteristics of the system, obtained by matrix. Solving relations and material status of the equipment is performed using models VAMY and VASY, which call for a network element matrix model calculation of voltage in knots. It's make an image of each element with the same parameters. [7]

B. The second part of the course consists of practical training in LW polygons. In Fig. 6 shows the OHL 220-400kV polygons [8].

The human operator will be ready to work under voltage installations, depending on technology, voltage system and risk factors to which it is subjected.

Interested staff, who first contact with this mode of work can prepare in LW initiation courses.

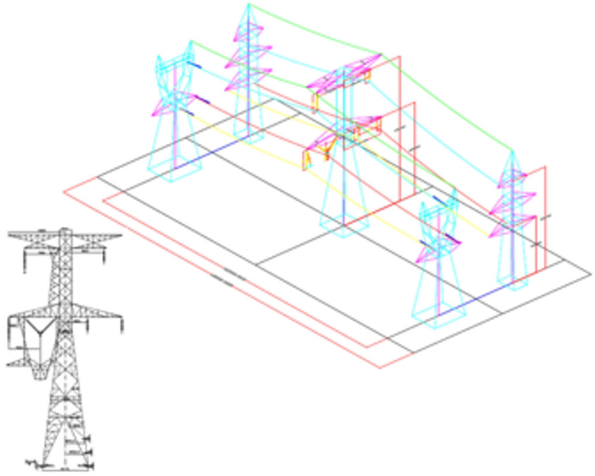


Fig.6. LW Polygon for 220-400kV OHL in the Centre for training [8]

3. EFFICIENCY OF TRAINING THE HUMAN OPERATORS

Applications of LW and new technologies to achieve maintenance of electrical installations have several advantages, including:

a) Increased network usage time (TPG or DPG, maintaining supply to consumers)

b) Reduced network losses

c) Eliminating congestion

d) Increasing economic efficiency (shown graphically in Fig.7 for LW technologies)

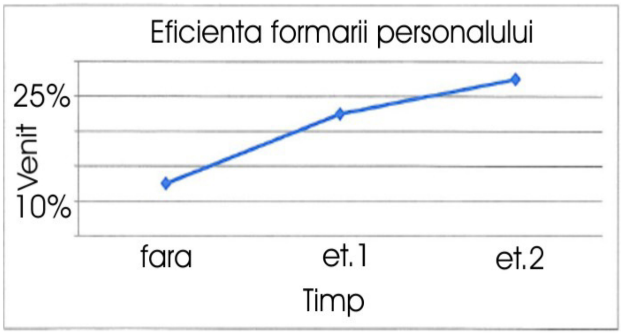


Fig.7. Economic efficiency obtained in training Centre

Getting results presented above is not possible without precise knowledge of the technologies.

The proper preparation for the execution of human operators to operating in maintenance using new technologies lead to quality of their works and more safely and to better management of maintenance activity.

The training of human operators in the training centre will be adequately achieve of works in beneficial installations by creating closest to reality conditions in the Centre.

In the last year were made of human operators training both in the country and abroad (e.g. Poland and Jordan).

Following the training of human operators were able to execute works with LW technologies, which are national premier, among which:

- Replacement of spherical buoy from groundwire of HV OHL using helicopter (Fig. 2)
- Replacement of the tension insulators from tower of OHL
- Replacing the anchor of port-anchor tower
- Technical inspection of OHL and substations by measurements in new technologies
- Replacement of the tension insulators from bus-bare in substations

4. CONCLUSION

Following studies accomplished reveal that the maintenance work by applying new technology, complete or only partially, become very necessary to increase efficiency and decrease costs for maintenance of the Company.

Decreasing maintenance costs is obtained by applying new technologies is significant. The efficiency of work with those technologies can be increased by making human operators training in a specialized centre.

In this way, in our Company has promoted a project which establishes the Training Centre.

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