MAINTENANCE OF ELECTRODISTRIBUTION EQUIPMENT AND ELECTRIC NETWORKS

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Abstract: In this report are quoted the main problems of maintenance of the electro distribution equipment and the electric networks. The problems which begin like consequence of a normal exploitation, and the age of same equipment elements, and the one which begins like a consequence of abnormal and careless maintenance. Every construction, arrangements or part of arrangement, observed like a technical system, are the composition of many constitutions, elements, respectively components with different characteristics in exploitation period. All the elements have different duration, different reliability and because of that they require maintenance. The admittance to the process of maintenance is very important because of organization, planning and bading process. Existing regulation treat maintenance of some system elements majory from aspect people softy and protection of property. Maintenance is very responsible and complicate work, but with good organization and necessary working discipline, it could be less problematic than it is today in cause of electro distribution companies.

1. INTRODUCTION

All events in general, which are happening around us, can be observed in systematic way, i.e. in their interconnection and dependence. It is very interesting, applicable and recommendable in technical system, their subsystems and the elements in maintenance. Systematically observed all elements and subsystems are in the mutual connection in some way and they have effects one on another, which is eventually reflected on the behavior of an entire system. From the other side, many environment factors which we should get acquainted with, are the system, they should be classified according to the intensity and location of influence, and to systemize by their importance, frequency and type.
With the analysis of quoted effects, getting acquainted with them and their surveillance, as well as the perceiving of causal-consequent connections in case of system fall out of function because of a break down, it is possible to foresee the other potential break downs as well. The break downs rarely originate independently; in most of the cases they are connected in such way that they could cause another one. With this approach it has been provided directing of attention on situations which are happening inside or outside of system, time and space related, and which lead to its unreliability.
The experts (educated personnel) are the most important factors in such approach. They should control the system in planned and organized way, to put in order the technical and other documentation necessary at every level of maintenance (regulations, instructions, rules and instructions of the producer and similar), to provide necessary parts for regeneration (actually for replacement), to provide the equipment and necessary instruments for maintenance and to work out the working methods adjusted to the existing maintenance equipment, and, when it is necessary, to increase the level of knowledge with the additional

education, on every maintenance level. Namely, the maintenance should be at higher level regarding the educated personnel, which is the main condition for increasing the system reliability.

2. THE WAYS OF SYSTEM MAINTENANCE

The main purpose of maintenance of electro distribution plants and networks is the maintenance of their exploitation characteristics, and through that their reliability also, with the purpose of achieving more efficacy. On question: “When it should be started with the maintenance of electro distribution system?” the answer is: “At the moment of beginning of exploitation”. Namely, with that moment the system begins to get old with tendency of change of exploitation characteristics. But with the process of age, the system starts to show different characteristics, and all that which differ from the normal characteristics gives the system the mark of unreliability (insecure ness). The reliability in delivery of electric energy to the buyers is a main criterion and the evaluation of a proper maintenance of the electro distribution plants and networks.
It is necessary to emphasize two aspects of the electro distribution and networks maintenance:

- **maintenance of plants in function,** actually their fast getting into the function in situation when system falls down.In this kind of maintenance we can classify the organized preventive maintenances, but also the “ad hoc”, unorganized, spontaneous. And also in this kind of maintenance we must classify two categories:
  - the system reliability against the fall down of a function (the exploitation level maintenance),
  - the system capability for bringing back into the function (the break down repair).

At the first category the maintenance has an important role, and in the second one those are the construction and forming of the system itself.

- **maintenance of vital characteristic of a system,** for distribution of electric energy at the satisfactory level through the planned, studious and successive regeneration and development. The regeneration means the replacement of used elements in the existing system with the unchangeable functionality which slows down the decrease of system vitality; actually the reliability is being kept on a constant level. Development of system means the introduction of innovations into the system in exploitation, actually the built system doesn’t have to be considered as definitive and final for its entire life span, but it has to be continually improved and in that way to increase the reliability.

To build a plant, and to not pay the necessary attention on the maintenance, means that this plant is condemned to quick ruination from the beginning of exploitation.
Frequent interruptions in the delivery of electric energy and even the ones with short duration, obviously show the bad maintenance.
In various reports which include the section “the cause of break down”, it is often written for the cause as “unknown”, which is also the proof of bad maintenance. But the term “unknown” which is many times used for the cause of break down suppose on two cases:

a) hiding the real cause of break down or,
b) uneducated personnel which take care about these reports.

If the break down cause is “unknown”, it is not allowed to shut down any plant or network several times a day, even if those shut downs are short. The passing short-circuit is for example the significant cause and if it repeat itself it is an obvious indicator of very bad condition and bad maintenance of the plant and network, but the cause can be relatively fast determined with professionalism and routine, and with good knowledge about the plant. But the explanation that the cause is unknown when the plant is often without tension for two, three or more hours can not be accepted. It doesn’t exist, at least today, a logical excuse, if the plant and networks in electro distribution did not perform the maintenance when the necessary preconditions are provided, and the material funds and educated personnel.
It seems that the maintenance plans are totally unnecessary or a burden for those who are obliged to make them. By these plans, there must be précised the time limits for inspection of the plant and when they are without a tension. After the inspection is over, detailed reports must be written and there will be shown what has to be done for the next inspection, and what is already done in this inspection. Unfortunately these reports are written shallowly many times, just because of a formality, and even many times incorrect too. The quality of report mainly depends on seriousness and pedantry of a person who is conducting the inspection. On the base of good report about the plant condition, is not the problem to do a proper preparation and to supply all material which is required, and in very short time without big ceases in delivery of electric energy to the buyers, to repair all break downs and to repair all potential locations of new break downs.
Installation teams, depending on the range of planned works on certain plant or network, should have an optimal number of workers and in any case it shouldn’t be allowed that the number of workers is bigger than it is really required. Even just one worker more in the team is disturbance for the work, and the work rhythm of an entire team is significantly decreased, because every worker has a certain premise and opinion like:

“that will be done by the other worker”. The result of surplus manpower in the team is, almost always, the extension of planned time limits for the work which causes the increase of costs of labor force and loss for undelivered electric energy to buyers. But the losses caused by the undelivered electric energy, are not stated in electro distributions. They remain somehow mysterious like no one wants to show them. Since these losses are not small it has to be found the way and method for their correct presentation.
Quickly repaired break down on network or plant, with use of inappropriate material or equipment, retaliates much more through the frequent break downs, although, sometimes, there are objective reasons for superficial repairing of break downs (because of short non-tension state in case of damage on the electric line, or in some plant which supplies some of “sensible” buyers – water supply company, hospitals, mines and similar). But on that place where the repair has been done in such way, there is a constant danger for return of break down. Because of that it is necessary to have a special report about those places, and by the first opportunity (on regular supervisions) the detailed repair of damage is to be done.
Very important element for maintenance of distribution plants and networks is the accurate technical documentation. It is not a rare case that for some plants and networks there is no any documentation because the facility was built a long time ago, so the preparation for works on such facility is complicated and hard work. It is almost impossible for doing the works on such facilities and to predict the supply of all necessary material, so the transport costs are increasing because that missing material is necessary to be transported on the place of work, and from the other side there is a significant loss of working hours.
The most important is that the buyers are left unplanned without the electric energy – which means that, on one side we get dissatisfied buyer (which is contrary to the adopted policy of quality in electro distributions which final goal is “satisfied” buyer), and on the other side again, there is the accumulation of losses because of the undelivered energy. The problem of completing and keeping the technical documentation, although there is enough of educated personnel for that, does not have an appropriate attention. Electro distribution plants and networks are such facility where there is always something to do and something is always happening on them. The changes, no matter how small they are, are so frequent, especially in the environment, and if we don’t register them in technical documentation, in very short period we can freely say that we do not have documentation for that facility. The facilities and plants we must consider as a live organism, and the addition and completing of their documentation as our continuous task. In the maintenance of electro distribution system in function, the attention must be paid on two important factors of electro distribution system:

- characteristic of the system,
- structure of the system.

The maintenance of system characteristic means the maintenance of exploitation potential of electro distribution system which is being, under the influence of different factors on the system in exploitation, decreased. In this maintenance there must be known the parameters of changes such as conditions and regimes of exploitation, purpose, they way of service and similar.
The maintenance of system structure means diagnose of system condition and a proper planning of regular activities for keeping the system structure (replacement of used parts, lubrication, cleaning).

3. PREVIOUS EXPERIENCES IN THE MAINTENANCE OF ELECTRO DISTRIBUTION SYSTEMS

The problems in maintaining the electro distribution systems begin already with the make of plan of regular maintenance, actually by making the Plan of repair of electro distribution plants. The repair (the inspection and repair of necessary parts of an entire system) of any distribution plant which supplies large number of buyers with the electric energy, it is impossible to organize, actually to make plans, which will be suitable to all buyers of electric energy. It is necessary to adjust the time of repair according to the character of all buyers who receive the electric energy from that plant: is that “sensible” buyer (hospitals, mines, water supply companies…), or it is a “big” buyer (hotels, industrial complexes…), and on the base of that to find a compromising solution. The sudden bad weather conditions or rain in the time of planned repair makes the situation worse additionally, because the planned works can not be done, and buyers, according to previous announcement about the planned stoppage, have done the necessary preparations. They disapprove this, but, basically, they understand the problem completely. During the consultation for the next stoppage they behave reserved and it is very hard to make the agreement.
In case of any works on distribution plant, the practice so far has shown that if the tension level is high then it is harder to adjust the time of stoppage of the plant, which is of course understandable because that kind of plant supplies a large numbers of buyers which technological process must be prepared for the period without tension so their production losses could be as less as it is possible. Until the issuing of Regulation on work protection for use of electric current (Off. Gazette SRBiH, no.34/88), the works under the tension conditions were not allowed which was additionally making harder the process of electro distribution plants maintenance. This regulation, in some hand, have legalized the work under the tension conditions (article

51 to 60 of quoted Regulation), with obligation to accomplish the cited conditions in article 51. By passing of this Regulation, on the base of statistic data, the number accidents have been decreased. The reason? Very simple: more serious approach to the works, the application of required organizational measures for safe work, and the possibility for plant to be put under the tension by mistake while the mounting workers are working on it, is eliminated.

Planning of repairs for plants and low-tension networks which mostly supply the buyers from category "households", is fairly less problem. It is enough to announce the stoppage in supply through the public information media, two or three days before the planned works. In case of works at the main lines, the number of buyers who are going to be without supply is large, and in those cases it is necessary to have more teams on the field so the period of planned stoppage could be accomplished.

Because of inadequate maintenance, the plants and networks very quickly come to the technical improper condition, which affects the efficacy of electro distribution system. The level of maintenance is lower, the plant is more neglected, and in that case it is more expensive and harder to reach the plant, actually to reach the network or required level of technical correctness. The practice so far has shown that the plant faster reaches the technically bad condition if:

- there are no regular and accurate reports on plant and technical documentation,
- there are no detailed and timely maintenance plans,
- there is no use of appropriate maintenance tool,
- the work is improvised by the installation of "similar" material,
- the maintenance is conducted unprofessionally and superficially.

Because of inaccuracy of plant technical documentation it can not be seen the real state of plant, and it is the first condition for inadequate and long lasting repair of damages. The cause for that is often non-coordination of departments where should be present the circulation of certain information about the plant: connecting of new buyers and increase of load brings with itself the control of protection and measure devices, control of supply lines section-planes, loading of energy transformers…

The use of inappropriate and damaged tools causes the damage of installed equipment (unscrewing the screw with mounting tongs instead of appropriate tool and similar). Because of non-quality performed preparation for work there are cases when the field teams only in the field realize that their material is not complete, and to avoid coming back to the company, they improvise on the field. The worst thing is that they don't register that "improvisation" anywhere, but they keep it in their minds, and after a certain period they completely forget about it, and in that way they leave an "open wound" in the system and the most probable location of the next break down. Unprofessional and superficial maintenance has heavier consequences on the system than the previously mentioned ones, and for which we have the examples from practice: inappropriate control of quantity and quality of insulation oil in the energy transformers, the omission of drawing tight the screw on the extracts, no control of grounding, inspection and cleaning the contact surfaces, control of heating of convergent and conductors, cleaning the cable cupboards, inspection of connection joints, control of tension reload transfers. Appropriate and quality maintenance in the first glance raises the price of maintenance works, but such work gives a guarantee for longer exploitation period of the plant and continuous supply of electric energy to the buyers. Any time when that is possible, actually when technical and technological conditions allow, the break downs should be detailed repaired, because we must have in mind that superficially repaired damage represents a potential danger for a new one, and in many times much harder damage on the same place. During the inspection of plant and network in the state without tension, the special attention must be paid on the condition of junction places. On the bad connected place or a bad contact, there is a big transition resistance. Because of large quantity of heat generated on that place the junction surfaces become hot and contacts become worse and worse, and according to that the losses of electric energy are increased. Frequent chars of electric joints (bridges) on the air lines are the result of inadequate control of their junctions. In some countries, for the purpose of easier detection of bad junction places, it is common the night inspection of electric plants and networks, of course in period of high loadings because it is very easy to see the sparkles on the bad junctions and contacts. The night inspections are not the common thing in our country, but following the fact that the buyer is important in this process and sensible for undelivered electric energy, such inspection will be brought into the practice.

4. GUIDELINES FOR CORRECT APPROACH TO THE MAINTENANCE OF ELECTRIC NETWORKS AND PLANTS

The main condition for rational and efficient maintenance of electro-distribution plants and networks are specialized teams made of experts, experienced and responsible workers. These specialized teams are the guarantee for achievement of high maintenance quality, high productivity of maintenance works with optimal use of mechanization and transport means and low losses of working time. In the forming of these teams we must reject the premise that every member of the team is able and should know how to do his work.

Such assumption is not just wrong but it is also harmful. The second important characteristic of specialized teams is that they shouldn't and may not have a large number of people, because of the reasons previously mentioned. Significant influence on the process of electro-distribution plant and networks maintenance has also a good preparation for works. Of those preparation activities I will mention only the ones which are the most important, and they are:

4.1. **Project and plant documentation**

For adequate and efficient maintenance of electro-distribution plants and networks, the quality processed technical documentation is very important, with the complete solutions of all specific details and complete data for all equipment. Every part of quality technical documentation has its purpose, and for that reason it should be used in a proper way. The built facility represents physical shaping of the project. So, the project documentation represents the base for making the technical documentation, and according to that the maintenance of that facility too. The quality project is almost more necessary for the maintenance, than for its construction. The exploitation and maintenance services in electro distribution companies must have demands for one copy of project documentation for each built facility, and according to that it will register accurately all and even the smallest changes on facilities in the plant technical documentation. For an example of importance of previously mentioned subject, I will take the air lines with middle-tension where there is a system of number of post places, it is to get data about the equipment of every base. But, the "Post lists" are not considered as necessary in the plant documentation and their accuracy was not conducting according to the field conditions (on the base of regular visit of DV). From the other side, it has the influence on the extension of maintenance works in the field because the condition and equipment of every post place can be determined only at the field.
The conductors of electric lines (long distance) and of the low-tension air lines, which are overgrown with tree branches represent the potential danger and cause the increase of loss of electric energy. From the other side even in the case of slight wind there are always short-circuits (usually just temporary), and also the stoppage in the supply of electric energy but just for a short period of time. Cutting down the tree branches represents the additional cost which has been made heavier because of a fact that is always hard to find a solution regarding the legal and property relations so the payments of compensation are always high. The policy of JP Elektroprivreda BiH, to use the self-carrying/self-supporting cable sheaf in the construction of low-tension air network, brought to decrease of this problem. With the use of self-supporting cable sheaf there is no need anymore for cutting the branch trees or the entire tree, so the payments of compensation to the owners are no longer necessary as well. The experience has shown that on 100km of network done with the self-supporting cable sheaf, we have only three break downs on a year, and such network is cheaper than the usual low-tension network for 10-20%. Until two years ago, the low-tension networks are being constructed on the wooden posts (pillars) whose life-time period is 5-8 years, and often even the shorter (depending on when these posts were cut off and how their impregnation process have been conducted). The self-supporting cable sheaf life-time is, according to the evaluations of French experts, 50 years. It means that during the life-time duration of self-supporting cable sheaf, it would be required to change those wooden posts for six or more times. There is no point to mention the cost amount for electro-distributions. This fact is a reason for another quality determination of JP Elektroprivreda BiH, for use of posts made of concrete. But the use of concrete posts requires, because of their weight, that electro-distributions have to equip themselves with quality machines for the installation of those parts. The similar situation is in the maintenance of cable networks, where the cable route is marked with concrete pillars or with small plates pressed into the asphalt areas. The problems rise during the digging out of cable because of a break down. If there more cables parallel placed in the cable canal of same type with the plastic marking ribbon which is placing in the canal above the cables, we are only informed about the tension level of a cable and not about the purpose of that cable. So, even if we switched off the damaged cable in the transformer station, we are still not sure which cable is without a tension. Because of that it is necessary to mark every cable with the badge made of plastic mass and to tie it onto the cable in canal or to lean it on cable and to wrap it with the bitumen ribbon on every 20-30 meters of the flat part of route and on every crossing with another underground cable. In purpose of easier and faster detection it is practical to make this plate in a different shape for each tension level, for example, for 1kV cables the square shape, for 10kV cables round shape, for 20kV triangular, for 35kV rectangular…
The cable distribution network installed by the electro-distribution, mostly in urban areas, has been installed solidly and it can be used for many years without almost any damages, of course if there are no any mechanical damages. But, the urban areas are the subject of constant digging up because of various needs of other communal companies, and on that account, especially if the construction machines are being used, the cables damage is taking a place. In case of damage of cables with the excavator or dredge machine we have a visible damage, but the cable have been fiber-loaded with a huge force in the length of 30-50 meters on each side, and on that length its insulation have been damaged. We have a proof for that in frequent breaking (piercing, drilling) of cable insulations exactly within those limits of the repaired place, and which is

logical because the humidity gradually penetrates through the damaged insulation. Because of that on these cables we have several damages, within 1-2 years after the first damaging. That is the reason why the cable routes should be marked as much visible as it is possible. Important factor which affects the quality of plant documentation are the land-register maps. But the fact is that the land-register maps, because of their age, are not equal to the situation on the field, with the exception of small number of city parts elaborated by the city planning. But there are also some difficulties because of often changes of electro-energy network in city areas, are required.

4.2. The preparation for work on the maintenance

The preparation for maintenance works begins from the moment of getting the license for use for built facility.
On jobs of preparation are needed experienced and professional personnel who with good maintenance teams can provide quality maintenance of electro-distribution plants and networks and gradually lead to the preventive maintenance. Work preparation must take care about the supplies of appropriate material on the stock, about technically good condition of transport vehicles and other machines and about their proper use, about the qualification structure and skill of some teams for the specific jobs, and about health condition of individuals and teams.

4.3. The influence of construction of facility on the maintenance efficacy

Although the existing legal regulations have defined the demand that the construction company must hold to, and according to that have assigned “the supervising body” which will take care about the legal enforcement of the Law on construction of facilities, it is a frequent case that this supervising has been just formally. It is especially the case when the mounting and construction of some facility has been done by the side of the own company. Namely, there is an enrooted opinion, although it is wrong, that the own teams do not require the supervision. But exactly the supervising bodies are the subjects which have to influence, with a strict control over the construction works that the construction of facility is done in accordance to the project documentation because it is the only way to avoid some bigger maintenance investments in the built facility during the exploitation.

4.4. The amount of transport means and their influence on the maintenance process

Large numbers of electro-distribution plants and networks on the entire distribution region of one electro-distribution requires the existence of its own transport means for people and material. The transport means must be ready and prepared at any time because of fast repair of damage at any location. Constant good condition of vehicles in technical means considering the different types of vehicles is not easy to achieve, especially those are the vehicles which require more drivers. Regarding the types of vehicles, the often case is lack and problems in supply of spare parts. The difference in vehicle types is of subjective nature, and represents the view of more different tastes. Because of that in the next period we must pay attention on unification of vehicles because in this way the vehicle maintenance costs are decreased.

5. CONCLUSION

The price of electric energy in our country is already high, so we can not expect the significant increase of its selling price. Namely, the costs for consumption of electric energy in households have reached the significant point and every further increase of price would affect on decrease of population standard. The share of costs for electric energy in the price of industrial product is also high, so in this case also the price of kWh can not be too much increased, because all of that would negatively affect the population standard. So, according to that, the increase of price of electric energy can be expected only within the limits of real planned overall increase of price.
Inevitable conclusion is that for a successful business of electro-distribution company is necessary to undertake the activities for decrease of working costs. First of all it is decrease of costs of present (regular) and investment maintenance. The attention must be paid on more rational use of working time, because those costs, as it is previously mentioned very high. There is no excuse for spending two or three times more hours for some works, than in some other countries.
I already mentioned that one of the determination in JP Elektroprivreda BiH, the use of concrete post in the construction of middle-tension and low-tension networks. The aggravating circumstance for application of this determination is insufficient equipped distributions with working machines for that installation because of their weight. I think that it is not exaggeration to say that the post (pillar) is problem number one for

distributions, from the aspect of its installation and from the aspect of its maintenance as well. Deficiency of wooden post is its short duration and frequent changes respectively, and regarding the concrete post it is its weight and the need for having the expensive working machines. So, I think that maybe, in this moment, the good idea is using the plastic pillars (posts) from polyester or formaldehyde pitch strengthened with cotton fibers.

In this time it is hard to talk about the price of polyester post which would be produced in BiH, because there were no similar calculations until today, but the prices of many other various polyester articles which are produced in BiH are telling us, that the price of that kind of post shouldn't be so high. The perfect self-supporting cable sheaf would in that case get a perfect pillar whose weight would be 60-70kp.

Determination which have been adopted at the level of JP Elektroprivreda BiH about the introduction of system of quality and getting the certificate of ISO 9000 group, has already given the positive results in the sphere of maintenance. By simple words, the introduction of ISO 9000 means that all previous works are still conducting, but now in one new and quality way with the obligatory application of entire phase control of performed working operations, actually works. Definition of every job with the appropriate procedure or instruction, with the application of appropriate documents of system of quality which are prescribed for that kind of work, inevitably leads to the increase of quality of performed works.

In accordance to that at the level of head office for distribution of JP Elektroprivreda BiH within the introduction of system of quality, the categorization of process which includes the complete activity of electro-distribution parts of company has been done. Within the determined processes the actions for performing of certain activities are defined, by the procedures and instructions. Concretely "The maintenance process in electro-distribution", by 5 procedures, 13 instructions and 14 forms of system of quality, has defined all necessary works and activities which are conducting for the purpose of maintenance of electro-distribution plants and networks in functional condition and their fast response in case of possible damages. With the application of other procedures from other processes (process of exploitation, process of planning etc), but consistent application, the maintenance work begins to get one new, more quality shape, the shape in which is possible to determine, precisely at any moment, who doesn't perform his work good and by the defined procedures, and in that way very quickly to prevent the arise of weak points in the system.

Key words: maintenance, technical documents, maintenance plan, supervision, revision, repair…

6. LITERATURE

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