

ROMANIAN ACTUAL POLICY ON MEDIUM VOLTAGE NEUTRAL TREATMENT

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Abstract: Single line-to-ground faults are the main type of failures in the medium voltage (MV) distribution systems. Those faults consequences depend on the chosen method for the neutral treatment (grounding) of the neutral point of the network. If the low impedance grounding is the preferred Anglo-French method, the resonant grounding is the commonly used one, for the rural distribution system in the Central, Northern and Eastern Europe, including Romania, Serbia and other countries. The paper presents the evolution of the methods applied to the Romanian MV networks neutral treatment (grounding), the basic criteria of this evolution and the recent improvements in the field, based on the last twenty years of own experience. In the 50' and 60' decades, isolated neutral/Petersen coils were used, without positive operational experience, caused on poor isolation level, of both aeri and cable network. Consequently, afterwards, in the 70' years, the neutral indirectly grounded was largely applied both to the underground and overhead lines. These method was associated with some new normes about the protection against touch and step protection in the network, aiming to reduce the expenses with the earthings. The indirect grounding neutral remain however, not entirely satisfactory, augmenting the number of the supply interruption of the consumers. Other experienced solutions were also several unconventional ones proved through "in situ" tests in different plants and networks. On the basis of own researces and our experience in this field, the tendencies regarding the overhead and underground networks were separated. Some experienced solutions are presented and consequently, the optimals considered were adopted as Romanian's policy for the near future. EU reglementation and news technological development lead to the chagement of our proposed for the future

KEY WORDS: neutral grounded through resistor; arc suppression coil - (petersen) grounding resistor technical policies

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1. INTRODUCTION.

MV network neutral treatment is a complex and controversial problem which has not been solved yet as a unique satisfactory solution to it has not been developed for all the cases. Fig. 1 synthetically presents the complexity of this problem by illustrating the main correlation among the elements that reciprocally influence one another within the different neutral treatment solutions. Not all the elements of the correlation in fig. 1 have got the same importance and the same share in establishing a strategy for the solutioning of the neutral treatment. The elements that are essential when choosing one or the other MV neutral treatment methods are: the continuous supply of the consumers; the influences on the en-vironment, the investment costs of the installations construction, and the technical conditions of the network operation. *cautati s comprimati fig 1*

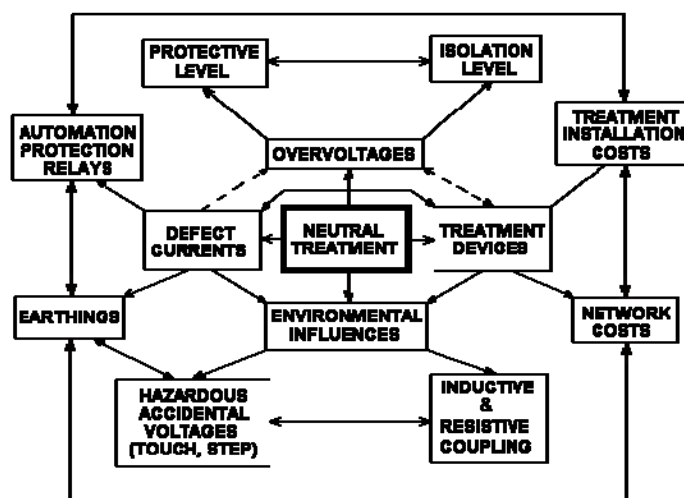


Fig.1

2. SHORT HISTORY

At the beginning of “the fifties” the Romanian MV networks generally operated without a “treated” (grounded) neutral. In general they did not cover large areas and had low capacitive current. The most important fact was that this treatment mode did not impose restrictions on the networks interconnection or on the operation with a single-phase fault (failure). The single fault-to-ground operation for a long period of time led to unpleasant consequences, favouring the double faults to ground during the search for the failure, due to the inadequate level of the networks insulation (insulators HD). The insensitivity of the protections against this type of fault in the MV networks with long axes, (characteristic of the first stages of electrification in Romania) led to non disconnected double faults. Consequently appears the loss of thermal stability of the grounding electrodes at the fault place and in several tragic cases, the penetration of dangerous voltages in the low voltage networks through the resistive coupling which had severe consequences. All these elements called for an intensification of the preoccupation towards the improvement of the isolation level of the networks and in parallel, to the optimisation of network configuration and of the neutral treatment solutions. The use of the neutral treatment through arc-suppression coils (ASC) (Petersen Coils - PC) leads to an improvement of the networks operational behaviours especially because it was accompanied by the unbreakable insulators use in the overhead networks. The efficiency of the ASC was still low in the cable networks. Moreover, the use of ASC made even more difficult and delicate the identification of the defect (faulty) line because the fault selection criterion was only the homopolar current amplitude. The ASC - treatment had in view the operation with the single-phase failure in network until this was identified. This was manually performed and could take up to 2 hours. The finding process was carried out by means of successive commutations which generated overvoltages that led to multiple faults to ground and tripping, with long-lasting interruptions in the consumers supply. Therefore the attempt at treating the neutral using the German method, led to the consumers disconnection in French solution. Consequently in “the 70 s” the implementation of the neutral indirectly grounded (NIG) solution (NIG-RN) taken over from Ed. F began to be applied. The promotion of this solution was facilitated by the improvement of the networks architecture (the increase in the number of injection points from the 110 kV network, the medium voltage lines loops-breaking, the axes length and derivations diminishing). This concept was also promoted by people specialised at Ed.F. This new method of treatment could not be largely used because of the Romanian safety regulations. The standards for electric safety had to be modified so that to enable the usage of this treatment method and protections and new automation means for this operation mode were developed. The method was equally applied to underground mixed or preponderantly overhead networks. In the underground networks to which the new treatment solution was applied important results were obtained. For instance the problems caused by the evolving faults or by the undisconnecting faults were solved (did no longer exist) while the network safety level was improved without a noticeable increase in the construction costs. Unfortunately the solution was considered a universal remedy, overlooking the fact that the noticeable results obtained also came from the previously taken steps to improve the network isolation. In the case of the overhead electric networks, the use of indirectly neutral grounding leads to an undesirable increase of the number of the consumers interruptions. For example in an ordinary overhead network, with protections which are 10 times less sensitive than those of the French networks of the same type (the protection acts at hundredths of Ohms resistance) the specific number of long time disconnection is of 4.5 long tripping/km · year against 0.6 on /km · year in the French networks. The majority of faults are temporary ones but they result in long lasting disconnection. The histogram of the overhead electric lines releases over a year is presented on fig. 2. The great majority of faults occur between 4 AM and 4 PM which suggests that the most frequently met cause is the drying phenomenon affecting the polluted insulation, which gets wet during the night time. mai

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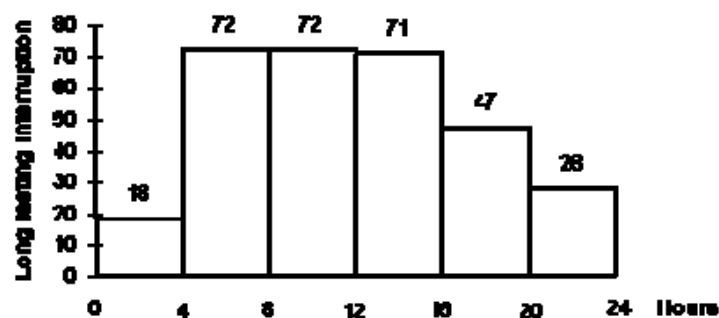


Fig. 2: Long lasting Interruption on MV line In one year

The disadvantages of this solution have much increased lately in the case of the overhead networks.

3. REMEDIES PROPOSED

The methods usually used for the neutral treatment aimed either at the decrease in the single line-to-ground fault current, in order to maintain this operational mode for a long time, or at limiting the voltage increase on the "healthy" phases by increase the fault current and the fast fault disconnection through the protection. In order to obtain a combination the advantages of the already known methods several "remedy" solution variants of our own devise have been applied.

3.1. THE ASC-RN SOLUTION

The main disadvantage of ASC (PC) use is due to the healthy phases overvoltages while carrying on operation with this kind of fault, which ultimately leads to the premature ageing of the non-regenerating insulation under these circumstances. The negative effects of this phenomenon are even more damaging in the case of a long lasting fault to ground [1]. Many faults of the one-phase grounding of the overhead MV lines are temporary ones, and disappear automatically when treated through PC correct tuned [2]. This suggested the usage of a combined treatment PC-RN in the same network. The solution was also successfully experimented in the Romanian overhead networks .

Usually the network operates with the PC tuned to resonance. When a single fault appears (of a low residual current) which is not solved through the coil, after a few tenths of a second, a grounding resistor is connected in parallel to the coil which leads to an approx. 300 A fault current, significantly reducing the "healthy phases" stresses, eliminates the occurrence of the intermittent arc and quickly trips the fault. Therefore the period of time when the "healthy" phases insulation is overstressed is diminished at the same time with its premature ageing. The solution was applied to several mixed-type networks (overhead and underground ones) and had good results. Nevertheless the necessary costs will evidently increase (grounding, supplementary artificial neutral, cells, protections etc.). An unconventional variant of this solution, which could be easily applied, is the one presented in fig.3 in which the grounding resistor itself is mounted in a specially designed winding of the Petersen coil. This variant avoids the use of an artificial neutral or of a MV cell for the RN resistor connection and bulky construction necessary for them. As the fault current adopted is diminished, the earthing plates is also significantly lower. The scheme operation is following. Usually the network operates with the PC tuned to resonance and breaker 4 open. If in the network a fault on an line (for ex. 7) will occur, the PC will perform its duty ensuring the automatic fault suppression. During this period of time on the faulty line the homopolar current is approx. null (equal to the residual current) and is not sensed by the maximal current protection (5) or by the homopolar one (6). Of the fault is not automatically extinguished by PC, 4 will be connected within one second. In this case, in the primary winding of the coil intensity will increase with the active component given by the secondary winding intensity I_{2B} . On the faulty line in this case, the active current increase ($I_{DEF} \propto W_2/W_1 \cdot I_{2B}$), where W_1 and W_2 represent the number of windings of the primary and secondary respectively. The circuit elements: W_2 , the sec. winding section, the value of resistor r (rn) mounted in the secondary winding will be established so that I_{DEF} be superior to the sensitivity limit of the homopolar protection (6) of the line (20 ... 30 A).

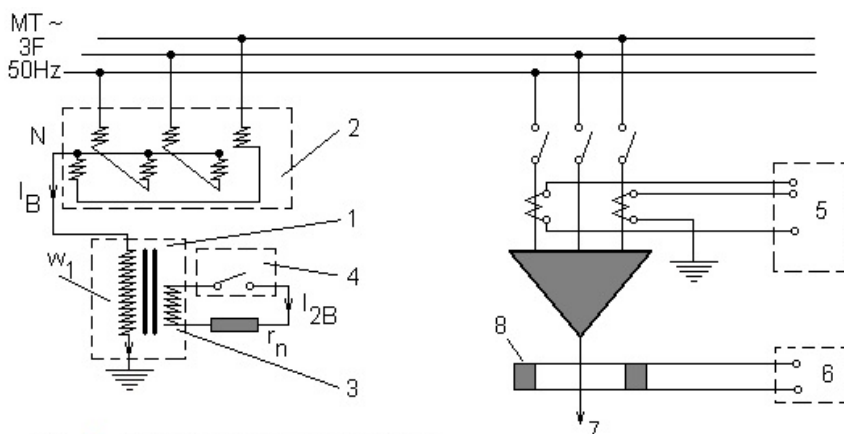


Fig. 3: ASC+Secondary resistor

1 - Arc suppression coil 2 - Neutral point coil (NPC) 3 - Secondary winding of ASC 4 - Breaker 5 - Maximal protection 6 - Homopolarity protection 7 - Departline (OEL/UEL aerial or underground)

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The circuit elements: W_2 , the sec. winding section, the value of resistor r (r_n) mounted in the secondary winding will be established so that I_{DEF} be superior to the sensitivity limit of the homopolar protection (6) of the line (20 ... 30 A). Therefore the line with the fault is disconnected, the breaker (4) is open and the network resumes its normal operation prepared for the treatment cycles, (PC- r_n). A substantial improvement of the neutral treatment by ASC results will be obtained through the use of the automatic tuning of the coil. A successful solution in this respect was the tuning based on the phase difference of the neutral displacement voltage from a fixed voltage one. The solution was applied to the overhead or mixed type (preponderantly overhead) networks.

3.2. SOLUTION WITH A SPECIAL MEASURING TRANSFORMER

For not extended cable networks with no accessible neutral point (for example in the case of the cable MV networks for the internal services of the power plants) the treatment through a limiting resistor can be performed as indicated in fig.4. **si in titlul figurii!!Textul de sub.fig ar trebui pus langa ea astfel ca sa umple pagina complet**

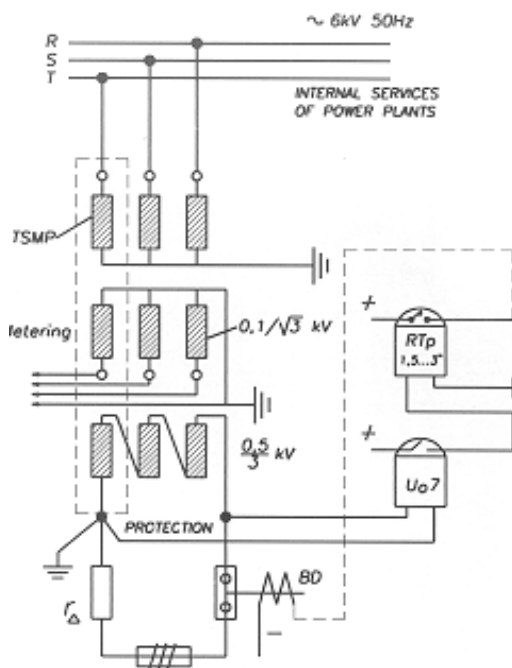


Fig.4: Special measuring and treatment transformers (TSMP)

Three special measuring and treatment transformers (TSMP) are used. They have two secondary windings and an increased rated power for short time. One of the secondary windings of this transformer is used for metering while the second one is connected in series with the adjacent phases, thus making an open triangle which is connected on a low value resistance (r_n).

In this way the scheme actually achieves through a single fault line to earth forcing of an active current determined by the value of r_n .

The high rated power consumed by the transformers from the healthy phases during ground fault leads to a great diminishing of the voltage to the ground and both of the overvoltages that affect the insulation of these phases. This effect in combination with the duration diminishing of the stress of the healthy phases through the fault line protection tripping makes this type neutral treatment practically equivalent to the indirect grounding. In this case the protections used in the network are simple, selective (maximum/homopolar) and rapid. In order to simplify the solution the breaker, from the TSMP secondary winding of the transformer will be kept closed in the normal scheme. Consequently the network will operate with the neutral indirectly grounded for 5 sec. after the fault occurrence (as long as TSMP and r_n are stables for 5 s). Afterwards, through the opening r_n the neutral become isolated. Is a relative relationship between r_n and the forced active current an the faulty line.[2] After the fault is cleared the breaker connected in series to r_n closes again and the network neutral again indirectly grounded.

3.3. THE SHUNT BREAKER

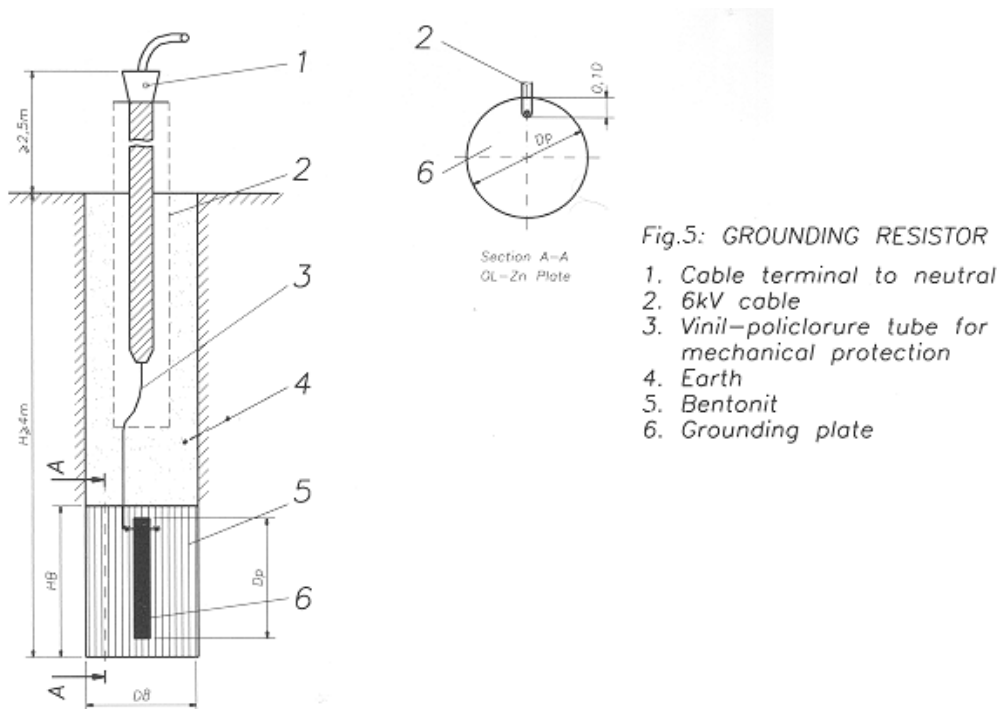
The solution with a shunt breaker has been experienced in Romania lately. It actually repeats the single-phase fault elsewhere in network through the connection, with a short time delay of a single-phase by a breaker close that reground the respective phase to the bussbar in supplying station. Meanwhile the current at the fault place is practically annulled and in most of the cases, the fault is cleared, (even) without the fault line disconnection. After the shunt breaker (switch) is opened the network will operate under normal operating conditions. The method was applied to an preponderantly overhead network, treated with a limiting resistor and proved to be highly efficient when was created artificially generated fault. We have not acquired necessary experience in the long time operation under this operations mode and its application requires single-phase switches which are not currently manufactured. The solution was not at large scale promoted..

4. LIMITING RESISTOR REALISED LIKE EARTH GROUNDING PLATE

Between unconventional methods adopted in Romania for neutral treatment (grounding) is the use of the non-metallic resistor realised like earth plate, with adequate dimensions.

To limit the seasoning oscillations of the earth resistance this is planted to an adequate depth ($h \approx 4$ m) and to assure the necessary thermal stability for five second the plate used like grounding resistor is mounted in an bentonite layer. The bentonite resistivity is with an size-order smaller than the soil and assure an excellent behaviour of the resistor realised in this manner at the thermal stress due to the passing of the single phase earthing current in soil.

The solution is illustrated in fig.5. These is adequate especially for the overhead and/or mixed networks (aerial preponderance) where the single phase to ground fault current is limited to 300 A. **comprimam fig o botezam 5 si punem text langa ea!!!**



Practical results of this grounding resistor was favourable and the realised economy in comparison to a classical solution is spectacular. The solution is adequate both for limiting resistor for medium voltage (RN) and for secondary winding of PC (rn) or TSMP (r \square) but in these two cases is very important to assure smallest seasonal oscillations of the resistance's values.

5. MEDIUM-TERM NEUTRAL TREATMENT POLICY

Taking into account the way in which the neutral treatment methods have been implemented in Romania and the experience gained in this field the authors used several particular solutions to solve the problems created by the necessity to assure reasonable expenses for the groundings necessary in the networks in the substation and at the poles in frequented zones..

The neutral treatment methods prove efficient only in the networks with the appropriate (corresponding) level of phase insulation. It is illusive to consider that the neutral treatment method can improve the quality of a certain network isolation especially if this is diminished by ageing or pollution. The treatment method influences the evolution of the phenomena in the network only after a single-phase fault occurs.

In the "technical policy" regarding the neutral treatment an important role is played by the experience acquired in the respective country. That is the reason why the inconsistencies represented by the passing of one to another treatment method are not recommended. This was repeatedly underlined by the Romanian experience.

Any treatment solution can be improved. Countries such as: Germany, Austria, the Scandinavian ones prove it through the notable improvements of the PC neutral treatment (protection optimisations, automation or regulating devices) that the neutral treatment through. The PC cannot be considered obsolete, fact proved by France where it will be again used in the overhead networks.

If in the case of the cable networks the majority of the specialists consider the grounding resistor represents the proper solution in future, in the case of the overhead lines the improved and correctly tuned PC is still a competitive solution.

6. LITERATURE

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