ROMANIAN EXPERIENCE IN ICING MANAGEMENT

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SUMMARY

Romanian networks were annually confronted with numerous incidents and desertions (failures) due to wind and ice, that have lately increased as a result of the climate changes determined by various phenomena (solar erruptions, el nino, maybe global warming, etc.). The paper presents the preoccupation of the Romanian specialists and department authorities to diminish the negative effects of the meteorological factors on the OHEL.Were used methods like initiation and materialization of "in situ" studies and researches about the real effect of wind and ice on the line elements, have improved the territory zoning in respect of the meteorological factors, were promoted new legislative regulations for OHL design and was applied the most modern and practical operational deicing methods, with preventive or/and effective character,based on objective warning solutions with original character..

The methods adopted and their positive effects are briefly presented, and some of the non-accomplishments, which make necessary that some specific indicators of the Romanian OEL deteriorations remain still ameliorable.

The paper has a pragmatic character, allowing the specialists to initiate discussions and exchange opinions in the frame of CIRED

Key words: OEL, climate,warning solutions, design, deicing

1. INTRODUCTION

The last years have not brought many changes or news in the field of OEL structure icing in Romania,as was the case of the USA, Canada or Japan. The measures taken in the past have rendered satisfactory enough results, especially because the recent period was a "mild" one from the 'meteo' point of view.The main measures applied, based on the experience obtained in the eighteen decade of the past century have been actually positive until the present time. But our concern still remains awake,in spite of the apparent diminishing in the severity of wind and ice influence on the network. Between 1970 and 2007 the evolution of the main indicators of OEL events (failures), especially on conductors and poles, influenced by ice and wind, was monitored. The annual evolution of these indicators, obviously shows that the desertions for conductors coherent with those of poles have the main cause the surpassing of design conditions taken in Romanian prescription The main categories of causes of incidents produced by wind and ice on OHEL are presented in Fig.1.The designed loads cannot be increased upon those economically, such solution leading to non-economically OEL On the other side, the majority of the OEL in operation cannot be easily upgraded;this means that operational methods must be used for their protection, as well. This fact justifies the strategy adopted for their protection against the unpleasant effects of icing and wind in the NPS (National Power Sys)

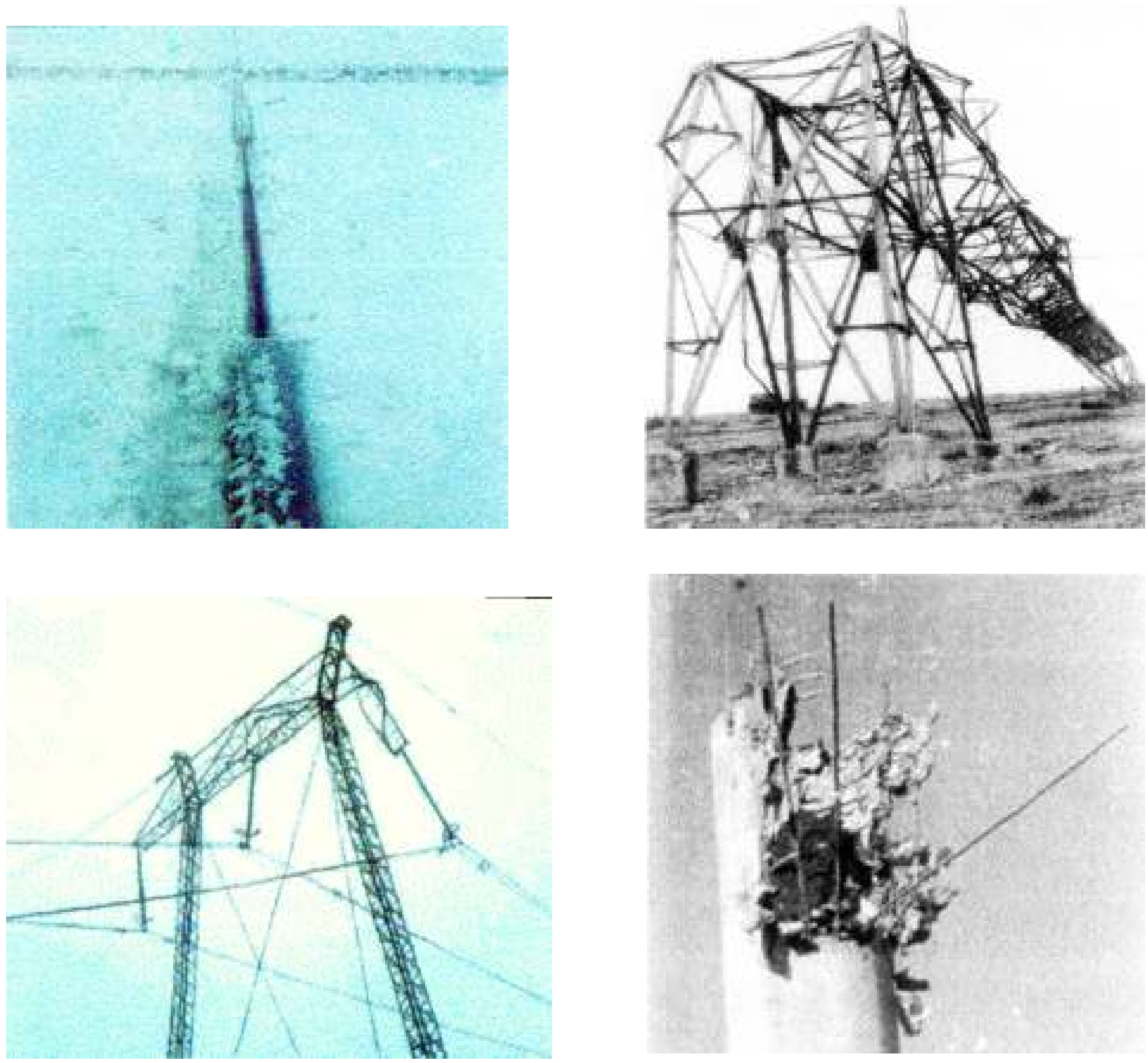


Fig.1 - Main kind of failures

2. DESIGN LOADS

To prevent incidents and diminish the unpleasant effect of the meteorological and climate factors on the NPS components,was acted by meteo-zoning of the country's territory,choosing more elaborate values for wind velocity and ice thickness, adopting modern methods of OEL structural elements design, as well as the methods of operational activity, had to be improved. This is possible by applying special methods of warning about the ice deposits,using solutions to prevent ice formation and improved methods of ice removal,especially by electrical methods.The initial values of the **basic** parameters for the OEL design, the so-called"computation loads", namely the wind velocity **v,** ice thickness **b**(the circular frost crown-of layer)**,**and its specific weight **g,** and air temperature fluctuation $\Delta\theta$ are presented in table 1[1].(*medium temp.at heigh upon 1000m)

INITIAL VALUES FOR v, b, and g

TABLE1

METEO ZONE	**WIND "v" VELOCITY m/s**	**WIND "v" VELOCITY m/s WITH ICE**	**WITE FROST THIKNESS "b" mm**	**SPECIFIC WEIGHT "g" kg/dm^3**	**AIR TEMPERATURE FLUCTUATION ^{0}C**			
					max.	min.	med.	ice
Is	30	15	17	0,5	+ 40	- 30	+ 15	- 5
I	25	15	17	0,5	+ 40	- 30	+ 15	- 5
II	25	10	13	0,5	+ 40	- 30	+ 15 (± 10)*	- 5

These values have been selected as to be similar to those from the former Soviet Union regulations in the field,having 3 meteo-zones: I, II and III.Based on the results of INMH, that have analyzed the data from about 150 meteo stations,uniformly distributed over the country's territory in more than 35 years, the initial zoning has been finally modified and improved(see fig 2).
The recorded data, with a normal distribution for **v** and **b,** allow to determine the average dispersion and the values, corresponding to an repetition frequency to1:5;1:10;1:15 and 1:20 years. With the average and dispersion values for different appearance frequency were established the **v** and **b** for OEL designing corresponding to an appearance probability once in 10 years for 110 kV including, and once in 15 years for OEL above 110 kV. Like for wind velocity, for ice thickness greater values are present outside Carpathian chain and on this reason, Romanian territory has been divided only in two meteorological zones, identical for both factors(fig.2). The actual values for **v ,b,** and their combination are presented in tab.2.(*More values upon operating experience)

ACTUAL VALUES FOR v, b, and g*

TABLE 2

METEO ZONE	$v_{m/s}$	$v + ice_{m/s}$	b_{mm}	g_{kg/dm^3}
I > 110 kV	36	22	24	0,75
II > 110 kV	32	19	20	0,75
I ≤ 110 kV	33	19	22	0,75
II ≤ 110 kV	26	14	16	0,75

The present meteo zones of Romanian territory are shown in Fig.2

Fig. 2 – Meteorological zones of Romania

Comparatively with previous editions of PE 104-designing prescription for OHEL,this regulation foresees that based on operational experience and objective information obtained from INMH,may be used much severe designing values,for news lines projects.The news interconection lines to UE , were dimensioned on this foresight,having more reliability.The statistic-probabilistic of OEL design vas adopted,in respect with IEC-826[2].For air temperature, were used the data from 300 meteo station,during 80 past years.From this point of vue,Romania should not be zoned,as the max.,min.and that of frost formation are +40,-30 and -5*C.Only the medium temperature represents a difference,(important for Eds calculations)for the areas at the altitude over 1000 m where is considered 10*C face on the rest of the country's terrain with 15 *C.Because the meteo station had not such possibilityes ,some of necessary designing data are still perfectible.Thus the vind speed variation with the construction height(**h)** was taken from referencies.The frost or ice density were considered the same: 0,75 kg/dm3.The variation of ice **b** versus **h** remain unknown,like ,otherwise the influence of conducctor twist when the ice deposit is blowed by the wind.Those supposition are imperfect,in much of our neighbours countrys are total other practice[3] but different design practice too.

3.ICE DEPOSIT PREVENTION

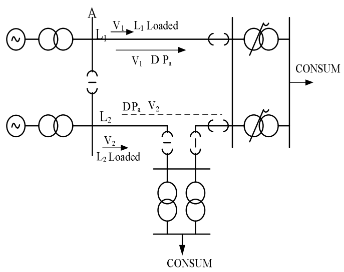
The fight with the negative effect of combined action of ice and wind may be made by designing and operational methods.In the phase of line design,is possible to choose lines path in manner to avoiding great deposits on lines conductors.In operational stage,in the line may be the conductor preheat,to mentain his temperature over 2..3 C.

3.1Optimal line path

Usually, the designer has few chances to choose lines path, by administrative and economical points of.vue. When they have the modality to take in consideration the arguments connected with the diminishing ice deposits,is indicate to follow some simple recommendations like the avoiding the empty hills,perpendicular on dominant wind direction, or ,by modifiyng a few line path to protect it of the danger due to meteo factors.In other cases is recommended to consolidate only one part of the line to protect the entire conexion between lines end.

3.2.Preventive preheating

One of most efficient method to prevent the ice accretion on lines conductors is the preventive preheating to mentain theyr temperature above some Celsius degrees.In this circumstance,the ice is much smaller that in the case of ice melting.That is the reason for which this method is preffered in Romania.The solutions necessary for preventive preheating consist in forcing the active or/and reactive power circulation,with/ /without operational diagrams change.(Fig 3 and 4)The necessary heating currents depend on air temperature and wind speed and are shown in Fig.5 for different Al/ST conductor's areas[3].To apply this techoology are necessary the forecasts of meteorological services or other objective signals from an original warnig sistem,described afterwards .



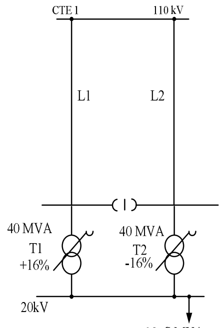
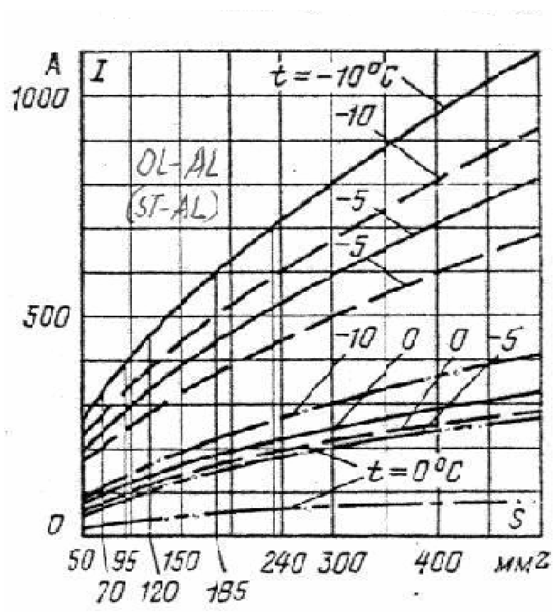


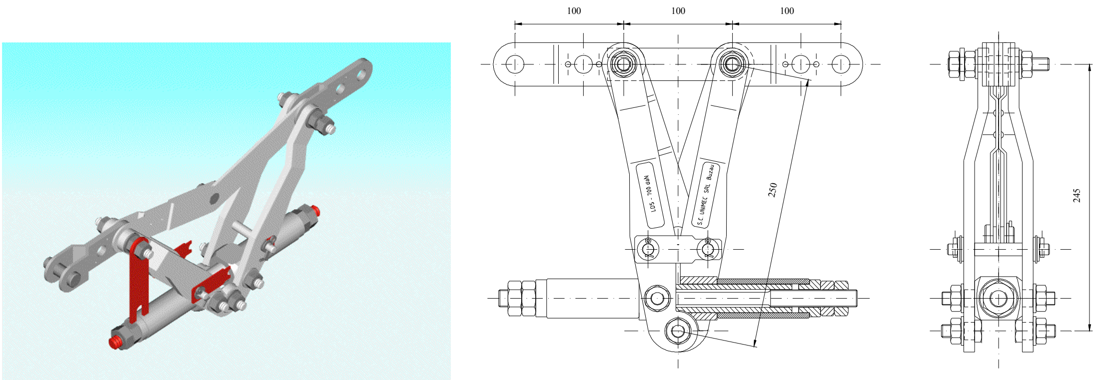
Fig. 3 – Active power forcing
Fig. 4 – Reactive power forcing



v = wind velocity: - v 10m/sec. – v 5 m/sec. - • - v 2 m/sec.
Fig. 5 Preventive preheating currents I (A)

3.3.Load limiter

Medium voltage lines with elastic insulation and deformable” coronament”are protected against overloads caused of ice and wind, with an device called LSD,presented as follows. .The stresses in the conductor’s line, may be decreased with the increase of conductor sag,in the openning,in some limits .In this purpose was realised the device,shown in Fig.6.a,b,c.In normal position,LSD,is mounted like in fig.6b.When the conductor axial load increase to an determined value ,a special fusible plate(red coloured) is easily, broken without shocks ,like in fig.6a,and the conductor sag increase.Thus decrease the conductor, pole and console’s stresses to convenient values,avoiding the extension of line’s damage.The return to the initial situation is very easy,by reextending the conductor ,compress the device and change the fusible plate.



a b c

Fig.6 Medium voltage load protector

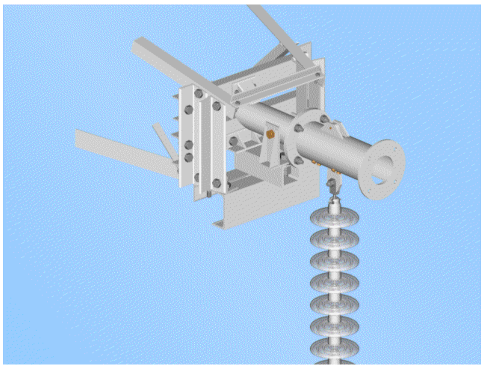


Fig. 7 DPM – pole protector

3.4.Poles protection.

Good operational results in decreasing the repairs indexes caused by wind/ice were obtained installing an other device-DMP-for high voltage poles protection,shown in Fig 7.He was designed,manufactured and experimented in cooperation by ISPE and ICEMENERG.It operates at transversal loads(wind,wind on covered by ice conductor),vertical frost loads exceeded,great longitudinal outbalance in the adjoining poles openings.The main element of DMP is one gauged screw to wich the pendulum P is hanged,with the insulator chain.

4.DEICING SOLUTIONS.

One of the methods for upgrading the behaviour of OHEL deicing,consisting in mechanical or electrical solution.The mechanical solution consist in apliyng isolated ropes upon the covered by ice conductors and puling these along the line opening.The solution is difficult and has a small productivity,each pole need to draw out the three ropes of the line phases.In medium voltage OEL were used and some isolated sticks.Both solution were applied only in wery rare cases,when other are not possible to be applied and the danger of line falling is evident. The most used and known method used in Romania ,in the areas with frequent ice deposits (rime, hoarfrost) which exceed the dangerous values,is the melting of ice layer.To us,the best known lines with this kind of problems are the 220 and 110 kV ones ,wich cross the chain of Carpathians mountains,but the technical possibilities to apply the method are not limited to this level of voltage.They can also be applied to the medium voltage level lines,but only in limited situations were the source of energy in prepared in advance.

There have practically created solutions and diagrams for the actual melting of ice ,for all 110 kV line and for some of MV lines,as for 220 kV lines crossing the western ,easter and meridional chain of Carpathes.At present isn't possible to apply the melting method to the 400 kV OHEL;practice has proved that its use has not been yet necessary .In reality,the possibility to create the necessary melting current for the phase from 3x300mmqACRS conductor section is possible only by feeding in DC current.The melting method is applied only when the preheating methods were not efficient-because the necessary power of this metodology is 2-3 times greather then for preventing ice deposit The opportunity of this method is subject of serious debates triggering almost opposite opinions and trends.The first trend considers that the melting method is difficult and complicated to carry out,as its implementation results in complications and great efforts in operation for keeping the consumers infeed.The uncertainty related to the line behaviour if deicing process had not been applied,diminishes the interest in applying this method and consider it efficient.The second trend considers the de-icing solution as a reliable method appliable on at large scale,with miraculous effects in respect to the improvement of lines behaviour and therfore of the sistem security. Obviously,even a superficial approach of the aspects connected with the scientific data of wich one can make an objective decision,the applying a melting method has an optional character.In Romania,the method is applied at a large scale, but not in the last period not beiing necessary.An wery useful solution for an objective decision for applying the electric melting is a warning system based on the telecontrol of ice weight. But no matter the deicing methods be improved and the endowment equipment could be updated the great incidents,particularly those given by glaze ice deposits with intensive wind speeds cannot be avoided.The diagrams preffered in the operational practice of RPS are inseries connecting of the necessary lines to assure the feeding from one bussbar at110 kV,or at one other prepared voltage to obtain the necessary heating current.

5. THE DEVELOPPED DETECTOR

The schematic diagram of the experimental warning system is given in fig.8

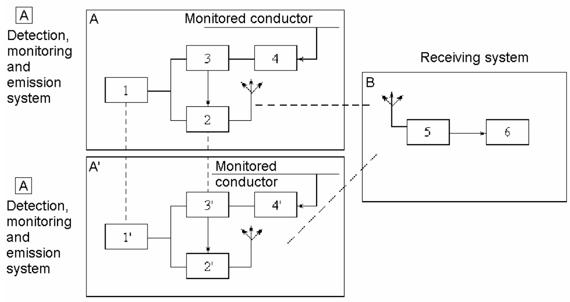


Fig. 8. Schematic diagram of a warning system.

1. Power supply; 2. Emission block of installation (EB) 3. Radioemitter (RE); 4. Transducer (T); 5. Radioreceiver (RR); 6. Installation receiving block (RB)

Detection, monitoring and emission system is made up of the following elements:

a) The detectors. In principle, there are three types of white frost detectors: radioactive, dynamometric and with load cell.

Utilising the principle of dampening the radiations emitted by a radioactive source to determine the danger of white frost depositing on the line conductors is advantageous because it enables the measurement of the deposit per unit of covered area (g/cm^2) favouring decision-making relating to de-icing; moreover, the result of the measurement is not influenced by the heterogenous character of the white frost deposit. An installation enabling a measurement of this type is robust and does not require maintenance, it can work even in the most infavourable weather conditions.For the moment, the problems that have to be solved for the implemention of this solution are rather complex and the price of this variant seemed prohibitive.

The tensometric transducer requires the utilisation of certain cells tensioning and compression. This way transducers for suspended or fixed (supporting) insulators can be performed that can be applied to medium or high voltage lines.
To a 250m span the variation of the current given by the amplifier between the moment when the conductor is covered and is not covered by white frost whose thickness should be signalled (b = 20mm) represents for the 185mm^2 conductor, 1.4mA, that meant a low sensitivity in the field of practical interest.
The low level of remanence (advantageous in the case of many applications of the tensometric cells) is a drawback in the case of this application as the conductor balance under the wind pressure can lead to false signals that have to be compensated.
That is the reason why the author do not consider this method competitive.The schematic diagram of a transducer of this type is given in fig.9.

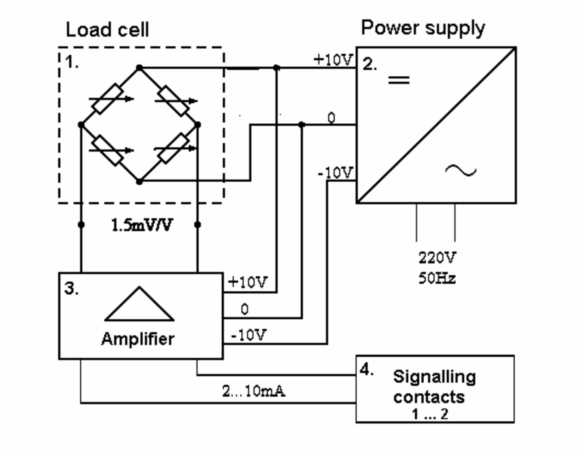


Fig.9The tensometric transducer-electric diagram

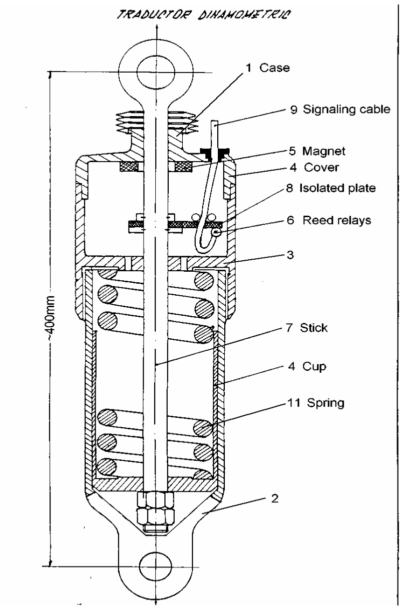


Fig.10.Dynamometric transducer with spiral spring and Reed relay

c. The dynamometric transducer

Taking into consideration the fact that efficiency of the de-icing methods is related to the phenomenon of stabilisation and to experience in operation, the most useful indicator relating to the danger represented by white frost is the thickness of the deposited layer. The normalized density is, in principle, 0.75daN/dm^3, so one can perform a direct equivalence between the white frost thickness and the weight of the covered conductor. It was considered useful that the weight of the white frost covered conductor trigger the danger signal.
The configuration of the mentioned transducer is presented in fig. 10. It is made up of four stainless steel cases with cover ($1 \div 4$) comprising a spring (11) subjected to compression. The increase of the spring deflection as a result of the white frost deposit makes the Reed relays to get closer to the magnet (5). The modification of the plate position (8) on which the relay is mounted enables the modification of the device sensitivity by modifying the force that makes the Reed relays for warning and for emergency close. The selection of the desired sensitivity is based on the experience in operation.
In order to avoid the undesired operations of the detector due to loads given by the wind (or combined), the signalling (emergency) contacts initiate the signalling process in the monitoring centre only after a $1.5 \div 2$sec. delay. Thus, the dynamic loads cannot initiate preventive or emergency signals.

d. The transmission circuit.

The modernized (updated) detector, as compared to that developped in the ‘80s, used an autochtonus radioemitter in the emission point and a radioreceiver in the monitoring point (the zone dispatcher or the OEL terminal station). The RE aerial together with the radioemitter was mounted on the pole with TD (dynamometric transducer).

By mounting the radioemitter somewhere high, in a metallic box, protects it against tampering and by mounting the aerial at a certain height increases the area covered by the emitter and improves the signal reception.
By encoding the signal we can monitor several emission points (up to 5) by means of the same reciving equipment.In operation certain limitations of the solution were noticed (especially due to the fact that only Romanian equipment had to be used) among which the limited area the RE can cover and the mountain relief conditions where the OEL are frequently covered by white frost, as well as the poor behavior of domestic batteries at low temperatures, when used for a long time.To improve this, power was to be supplied from the monitored line (inductive by means of a voltage transformer or capacitive by means of an isolated conductor, parallel to those of the monitored OEL).In both cases, the power taken was used to heat the box where the RE and battery was mounted. These complicated solutions proved to be non-competitive so that, in the end, a competitive DC battery was preferred, whose operation in the real operating conditions during the frost depositing period of time was guaranteed. Besides this, in the adopted communication solution the battery status can be permanently tested. The problem relating to the relief conditions was solved by utilising the satellite transmission, by means of the ORBCOMM network. The operational diagram of the communication system utilised for the signalling system mounted on the Alesd-Suplac 110kV OEL is presented in fig.11.Was also used an old transmission variant using the conductor of the monitored electric line)

Fig. 11. The mentioned communication system

The coordinates of the supervised point, situated in the most dangerous zone of the line (station 85 of the OEL) are 47°7’35” latitude North and 22°28’42” longitude East.
The point where the warning and the emergency signals are received is the zone dispatcher. We should mention that a reception point can monitor several points on the monitored line.
Information is received at the receiving point in the form of e-mails on the computer, indicating the condition of the warning and emergency contacts and of the power supply battery.
Thus, any deviation from the normal status can be corrected, ensuring the well functioning of the white frost detector.

5. CONCLUSIONS

The experience obtained in Romania in the decades of great RPS development allows to assure satisfactory operational behavior indexes of overhead electric lines. In this respect were used different solutions between which the preferred are the preventive ones. The effective methods consist in ice melting of formed rime layer upon conductor,signalised by an objective device. The stochastic character of OHEL loading do not assure that in the future will not remain incidents caused by ice and wind or their combination in OHEL

List of referencies

[1] **PE 104-**94 Prescriptii pentru constructia LEA .ANRE ed.2004
[2] **SR-CEI-60826** Proiectarea liniilor electrice de IT
[3] Goia,L.M.Experienta romaneasca in combaterea efectelor chiciurii asupra liniilor electrice. FOREN 2008 - Neptun,Romania