Proceedings of the 5th WSEAS Int. Conf. on Power Systems and Electromagnetic Compatibility, Corfu, Greece, August 23-25, 2005 (pp125-129)

A Power Line Radio and Ultrasonic Interference Environmental Study

I. S. HALKIADIS
Department of Electrical Engineering
Technological and Educational Institution of Chalkis
34 400 Psahna, Euboia
GREECE
http://www.ee.teihal.gr/labs/electronics/web/

Abstract: - An experimental study has been carried out to find the effects of environmental aging surrounding on the radio and ultrasonic noise characteristics of single strand aluminium conductors used by electric companies for 400 kV transmission lines. The performance of similar conductors been energized at equal time periods under the same voltage stresses in the H.V. laboratory and in an industrial area, was investigated. It was found that samples energized outdoors exhibited lower radio and ultrasonic noise levels than those emitted by identical conductors energized indoors in the H.V. laboratory. Further tests emphasized that there is a close relation between the radio noise emitted by the conductor and the environmental conditions to which the conductor is exposed.

Key-Words: Transmission line, Radio noise, Ultrasonic noise, Aluminium conductors, Conductor aging, Corona.

1. Introduction

Due to the proliferation of new sources, like mobile and wireless communications and the increasing number of radio receptors, the engineering study of radio noise emitted from transmission lines, has assumed much greater importance in recent years. Power-line noise can interfere with radio communications and broadcasting. Essentially, the power-lines or associated hardware improperly generate unwanted radio signals that override or compete with desired radio signals. Power-line noise can impact radio and television reception including cable TV head-end pick-up and Internet service. Disruption of radio communications, such as amateur radio, can also occur. Loss of critical communications, such as police, fire, military and other similar users of the radio spectrum can result in even more serious consequences.

Transmission line interference is primarily caused by partial discharges of the air (corona) in the immediate vicinity of the conductor, when the electric field intensity at the conductor surface exceeds the breakdown strength of the air. The produced corona induces impulse currents on the line. These currents, in turn, cause wide band electric and magnetic “noise” fields that fill the entire frequency spectrum from below 100 MHz [1]. Specially in A.M. band, pulsating corona will cause audible radio interference produced at the output of A.M. radio receivers.

Measurements of audible and radio noise carried out and recorded continuously for 2 years in a 400 kV operating line in Sweden showed a considerable reduction in both quantities at the end of the measuring period [2].

Various factors influence the corona inception voltage. Studies in the mechanism by which a new aluminium conductor ages in a non-energized environment show that 4-month-old conductors responded with a higher corona start voltage [3].

Long term measurements made in a 230-kV compact line confirmed that radio interference was much lower than predicted for new installed conductors [4].

Predicting audio line performance and corona onset voltage, have become main considerations for overhead line designers [5], [6].

One of significant importance on the ultrasonic and radio noise performance is the surface condition of the conductor. Observations have shown that a natural black deposit is formatted on the surface of the conductor when a transmission line has been in operation for some time. This is known as conducting aging. Investigations carried out on conductors aged for different periods and under different surface treatment show that a black deposit which consists mainly of sulphur, carbon and oxygen tends to be formed on aged conductors after about a week of operation [7]. A possible explanation about the formation of this surface deposit is that the electric wind, in the form of air jets directed away from the corona discharge points, induces local air circulations which promote the flow of a varying amount of airborne materials over the surface of the conductor where they are retained giving the conductor surface a darkish coat.

Although the relation between aging and radio noise interference has been clearly stated, there is a lack of information, at least not in author' s best knowledge, of the influence that the surrounding the conductor atmosphere, during aging, has on its radio noise performance.

With radio and audio noise being very important design criteria for overhead line conductors the effect of the atmospheric surrounding on them must be accurately known. The aim of the present investigation was to determine whether radio and ultrasonic noises emitted from conductors aged in the laboratory, differ from those emitted by the same conductors aged outside in an industrial area where the atmosphere surrounding was highly contaminated. Furthermore tests were made to investigate the absence of atmospheric contamination and the influence of airborne particles on radio noise levels.

2. Experimental procedure

The configuration used in the experiments, whether performed inside or outside, included a single conductor above a metal earthed plate as seen an Fig. 1 where the experimental setup used in the H.V. laboratory is shown with H.V. transformer on the left, coupling capacitor for radio noise measurements on the right and surrounding metal security frame.

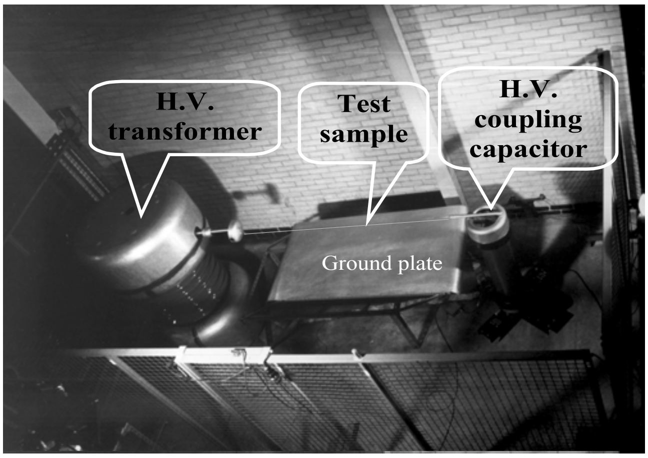

Fig. 1. Experimental physical set-up in H.V. lab.

The voltage gradient at the surface of the conductor was controlled by the metal plate supported by an adjustable stand.

For radio noise measurements we used a radio noise meter designed to measure radio frequency noise voltage and the fields generated by electrical equipment in the frequency ranges of 150-400 kHz and 0.55-30 MHz. The meter was connected to the test circuit through a decoupled unit, which consisted of a matching resistor, a radio noise inductor and a spark gap. The radio noise characteristics were obtained at frequency of 1 MHz.

For recording ultrasonic noise, a fiber optic acoustic wave-guide, with a 40-kHz ultrasonic transducer was implemented, placed very close to the test conductor so that the attenuation of the sound wave and its contamination from the ambient noise were highly reduced.

Before testing, the surface of the conductors was cleaned with petroleum ether since surface oil is found on conductors as supplied by the manufacturers.

Test conductors can be divided into four groups:

a) those aged in the H.V. laboratory where the atmospheric pressure, ambient temperature and relative humidity remained approximately C^0 20, 755 mm Hg and 55% respectively;
b) those aged outdoors in an industrial area as shown in Fig. 2;
c) those aged in the enclose of a sealed 15 cm diameter aluminium cylinder;
d) those sprinkled with talk powder.

Fig. 2. Conductor under aging, outdoors

All test samples were carefully handled to avoid mechanical stress and abrasion defects. As a result the conductor surfaces were completely untouched and presumably were in the same condition at the time of testing as they were while aging.

The effect of the surrounding atmosphere on the appearance of the surface of two test samples can be seen in Fig. 3. Both samples shown were aged for 550 hours at 37.6 kV/cm. Sample (a) was aged indoors and sample (b) outdoors. As can be seen, that aged outdoors presents a darker surface blackening.

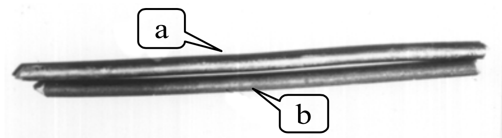

Fig. 3. Physical appearance of two samples aged for 550 hours at 37.6 kV/cm; a: aged indoors, b: aged outdoors.

3. Radio and ultrasonic noise characteristics

Radio noise level versus applied voltage characteristics, of two conductors being tested under the same conditions but in different environments, are shown in Fig. 4. It can be seen that the radio noise produced by the sample aged in a polluted atmosphere is lower than that produced by the sample aged in the laboratory. The difference is becoming slightly higher as the applied voltage is emerged. It can be seen that the radio noise produced by the sample aged in a polluted atmosphere is lower than that produced by the sample aged in the laboratory. The difference is becoming slightly higher as the applied voltage is emerged

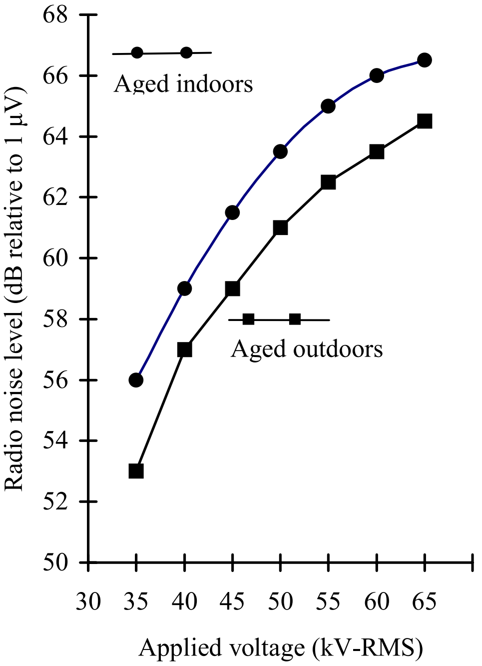

Fig. 4. Radio noise levels of two identical samples aged for 550 hours at 37. 6 kV/cm, one indoor and the other outdoors.

Results recorded for ultrasonic noise characteristics of the same samples, are shown in Fig. 5. Compared with those of radio noise it can be seen that they follow the same patent. The lowest ultrasonic noise level is exhibited by the sample aged outdoors. The difference of noise remains almost steady through the entirely applied voltage range. A plot of the ultrasonic noise level against radio noise level was made for each sample and is shown in Fig. 6. It can be seen that the ultrasonic noise levels are directly proportional to the generated radio noise levels.

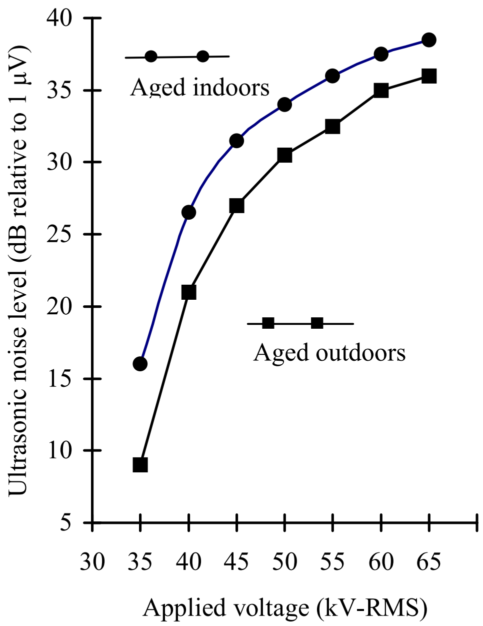

Fig. 5. Ultrasonic noise level of two identical samples aged for 550 hours at 37.6 kV/cm, one indoors and the other outdoors.

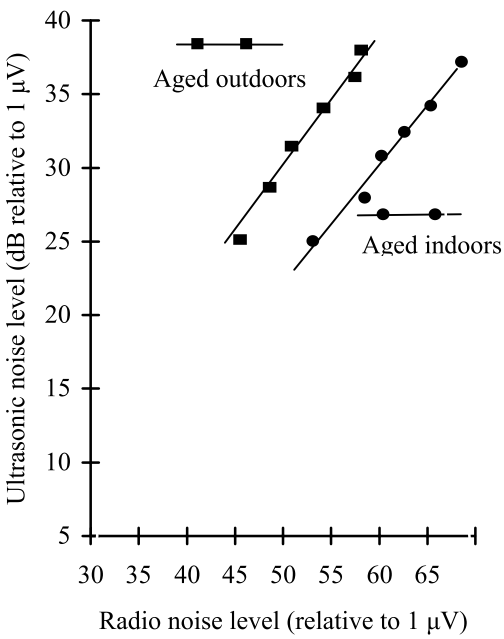

Fig. 6. Ultrasonic noise level of two identical samples aged for 550 hours at 37.6 kV/cm, one indoors and the other outdoors.

All results obtained so far indicate that atmospheric surrounding influences the radio noise level of aged conductors. In order to make sure that this is the case, one more test, which could give us a higher emphasis in our conclusions, was performed. The procedure was to put a sample in the middle of a 15.4 cm diameter aluminium 1.70 m long cylinder. Both of its ends were closed by two pieces of thick Perspex with a small hole

Proceedings of the 5th WSEAS Int. Conf. on Power Systems and Electromagnetic Compatibility, Corfu, Greece, August 23-25, 2005 (pp125-129)

in the middle. The sample was passed through and was running along the center of the cylinder without the atmospheric contamination being able to enter the inside of the cylinder. The cylinder was earthed and with an applied voltage of 23 kV-RMS, an electric stress of 37,4 kV/cm was created at the surface of the conductor which was aged inside the cylinder for 250 hours. Measurements of the radio noise level of this sample compared with that of a non-aged sample and another aged indoors outside the cylinder, at 37,4 kV/cm for 250 hours, are shown in Fig. 7. It can be seen that there is no difference between the radio noise exhibited by the sample aged inside the cylinder and the non-aged sample. In contrast a significant lower noise level is exhibited by the sample when aged outside the cylinder for the same period of time. That is a clear evidence that the radio noise reduction is closely related to the atmospheric surrounding.

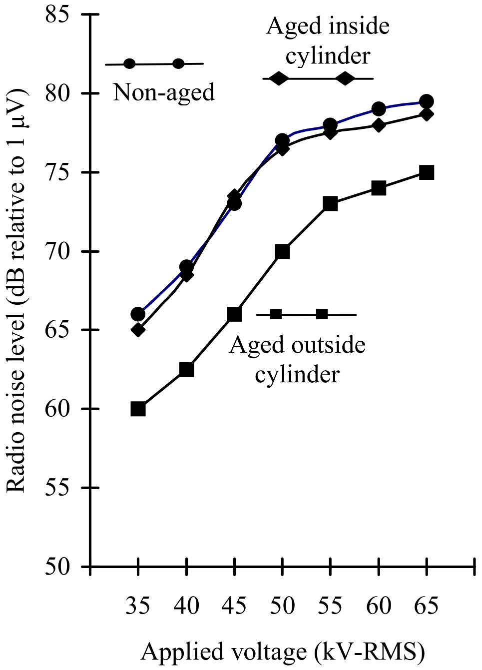

Fig. 7. Radio noise levels of three samples. One non-aged and two aged for 250 hours at 37.4 kV/cm, one inside cylinder and one outside cylinder.

Until that point our investigation made clear that the radio noise performance is greatly influenced by the environmental conditions to which the conductor is exposed. To understand the effect of atmospheric airborne particles on conductors, one more test was run in the laboratory. A sample was sprinkled with talk powder over its entire length. Of course talk is not an airborne substance but it was used because it was at hand and it could be of help in approaching a significant conclusion. The sample was aged for 50 hours at 37.6 kV/cm and its radio noise characteristics, at the beginning and at the end of the test, are shown in Fig. 8. In the same figure the radio noise characteristics of a non-aged sample and another aged indoors for 450 hours, are shown for comparison reasons. It can be seen that even at the beginning of the test without any aging, the presence of talk powder on the surface of the conductor reduces its radio noise level. After an aging period of 50 hours the sprinkled with talk sample reduces its radio noise at the same level emitted by a non-sprinkled conductor aged for 450 hours.

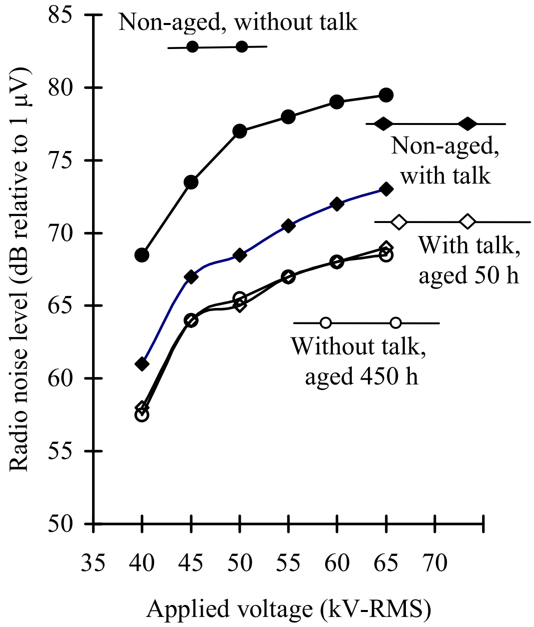

Fig. 8. Radio noise levels of four samples. One non-aged. Three aged at 37. 6 kV/cm: one sprinkled with talk aged 0 h, one sprinkled with talk aged 50 h, one without talk aged 450 h.

4. Conclusions

Investigations carried out on conductors aged in different surroundings show that:

(1) aged conductors experience reduced radio and ultrasonic noise;

(2) there is a difference in radio and ultrasonic noise levels between conductors aged in different atmospheres;

(3) samples aged outdoors in an industrial area, exhibited lower radio and ultrasonic noise than those aged in the laboratory;

(4) samples aged in an isolated enclosure, presented no difference in radio noise from non-aged samples;

(5) equally spread powder particles on the surface of the conductor, reduce radio noise level. The reduction becomes more intensive after aging.

References

[1] J.M. Silva and R.G. Olsen, Use of Global Positioning System (GPS) Receivers Under Power-Line Conductors, *IEEE Transaction on Power Delivery*, Vol. 17, No 4, 2002, pp. 938-944.

[2] C. Larsson et al, Long term audible noise performance from the operating 400-kV transmission line, *IEEE Trans. PWRD,* Vol 3, 1988, pp. 1842-1846.

[3] J. R. Booker, Natural aging of non-energized aluminium conductors, *IEEE Trans. PWRD*, Vol. 1, 1986, pp. 269-274.

[4] V.L. Chartier et al, Corona Performance on a Compact 230-kV Line, *IEEE Transactions on Power Delivery*, Volume 10, No 1, pp. 410-420.

[5] Kwang-Ho Yang et al, New formulas for predicting audible noise from overhead HVAC lines using evolutionary computations, *IEEE Transactions on Power Delivery*, Volume 15, No 4, 2000, pp. 1243-1251.

[6] K. Yamazaki et al, Application of a corona onset criterion to calculation of corona onset voltage of stranded conductors**,** *IEEE Transactions on Dielectrics and Electrical Insulation*, Volume 11, No 4, 2004, pp. 674-680.

[7] I.S. Halkiadis, An auger electron chemical surface analysis of differently treated conductors, *MedPower'04*, Lemesos, Cyprus, November 14-17, 2004.