INVESTIGATIONS OF ELECTROMAGNETIC COMPATIBILITY (EMC) OF VEHICLES USING OPEN-AREA PARTIALLY SHIELDED TEST SITE MODEL

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Abstract

The technological development in automotive industry that can be observed during the last several decades, especially during the last decade, causes that share of a vehicle electrical and electronic equipment constitutes over 30% of its total worth. This equipment essentially affects the safety of the driver and passengers as well as the driving comfort. In order to fulfill the growing requirements in the range of vehicles safety and reliability, conducting of numerous tests of the electrical/electronic equipment, including tests of electromagnetic compatibility, are necessary. As is known, EMC tests are expensive and difficult to reach, mainly due to the necessity of employing very expensive absorber-lined shielded test chambers. For this reason, there is a need for studying more accessible and less expensive EMC test methods, in particular, by using open-area partially shielded test sites (OAPSTS).

In this paper, a model of OAPSTS is described. The model ensures that the tested vehicles are partially separated from the environment by shields attenuating electromagnetic waves. These shields have been made of electro-conductive fabrics worked out in Poland. Tests of vehicle immunity to electromagnetic radiation have been performed using the model of OA PSTS and the following vehicles: Skoda Octavia 1,8 and Daewoo Lanos 1,6. Estimation of parameters of the OAPSTS model for four variants of absorbers placement has been worked out. The tests have been performed according to EU Directive 2004/104/EC and ECE UN Regulation No. 10.

Keywords: *transport, motor vehicles, EMC tests, open-area partially shielded test site*

1. Introduction

As is known, the question of testing motor vehicles and their subassemblies, in particular in the range of electrical and electronic equipment, is very important. The scope of the relevant tests becomes wider and the requirements, especially in the range of passive and active safety, reliability and driving comfort, become higher.

Automotive electric and electronic devices, during their operation in a vehicle, are exposed to various environmental factors of different physical nature. Among most important factors we can list the following:

a) electrical/electronic devices are exposed to disturbing interactions between them by means of galvanic conduction, inductive and capacitive couplings or by means of radiated electromagnetic emissions,
b) these devices can be exposed to high voltage signals,
c) they can be exposed also to voltage or current pulses with relatively large energy and very short duration time; these pulses appear in the wiring harness of a vehicle,
d) these pulses can affect the driving safety,

e) electrical/electronic devices are placed inside a relatively low volume enclosed by vehicle dimensions; their number is relatively large, they are connected by cable bundles with a large number of electrical connections,
f) some of these devices can be exposed to cooperation with other which show defective operation,
g) they are exposed also to impacts caused by vehicle collisions,
h) during normal operation in a vehicle they are exposed to mechanical vibrations (with variable accelerations and amplitudes), varying temperature, humidity and dust,
i) they operate in the environment in which operate also various devices that are not designed for operating in vehicles, that is frequently with other EMC parameters than for automotive devices, for example with audio-video receivers, radio-stations and personal computers,
j) electrical/electronic automotive devices are exposed also to outdoor disturbing signals caused by other vehicles, road infrastructure, industrial infrastructure, radio transmission, etc.

According to the obligatory international regulations concerning the approval of vehicles and their equipment with regard to electromagnetic compatibility, i.e., ECE UN Regulation No. 10 and EU Directive 2004/104/EC, EMC tests include:

1. examination of radiated emission,
2. examination of conducted emission:
   - in supply lines,
   - in signal lines,
3. examination of immunity:
   - to electromagnetic radiation,
   - to impulsive signals in supply lines and in signal lines,
   - to electrostatic fields.

The most research and technical problems appear when the vehicle immunity to electro-magnetic radiation is examined.

2. Model of open-area partially shielded test site (OAPSTS)

The worked out model of OAPSTS is designed for immunity tests of vehicles to electromagnetic radiation. The main goal of the research is to determine possibility of applying in EMC open-area test site examinations of absorbing shields, made of multilayer textile material containing conductive fibres, and absorbers, made of polyurethane foam saturated with carbon. The model of OAPSTS enables us to determine spatial decomposition of the electromagnetic field strength (electric component of e-m field) in vehicles as well as to examine the new EMC test method that has been proposed in Grant No. N509074533.

As the objects of EMC tests in OAPSTS small cars with overall dimensions do not exceed 4.8 m in length, 1.8 m in width and 1.8 m in height can be considered.

The model of OAPSTS consists of shields made of electro-conductive fabrics of the types WOM-E1, WIEP-20 and WAF-450 which have been worked out in Instytut Włókiennictwa in Łódź. The individual shields of the OAPSTS have been made of three layers of WIEP-20, three layers of WOM-E1 and one layer of WAF-450. The characteristics of electromagnetic waves attenuation through the shields are shown in Fig. 1. Three segments of absorbers HPF60 have been placed inside the model of OAPSTS. The model has been installed in Centralne Laboratorium Badań Technicznych UKE in Borucza near Warsaw. A view of the model of OAPSTS is shown in Fig. 2.

3. Objects of investigations

The objects of investigations are the vehicles: Skoda Octavia 1,8*l*, 150KM and Daewoo Lanos 1,6*l*, 106KM. These vehicles were previously tested in an absorber-lined shielded enclosure (ALSE) in CLBT UKE in Borucza according to EU Directive 2004/104/EC. The technical data of the vehicles as well the results of these tests can be found in [6].

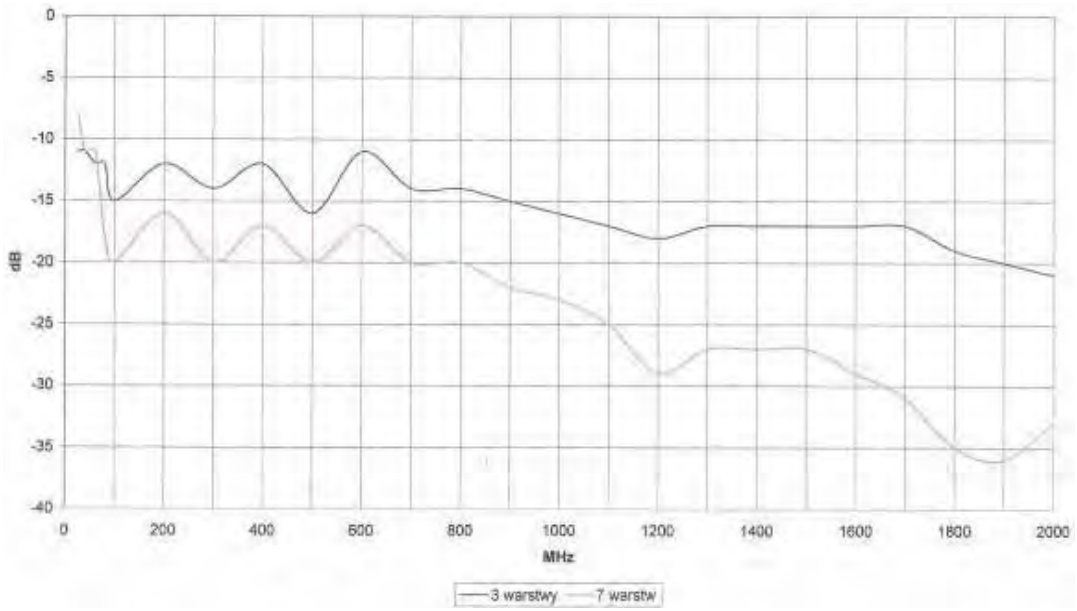

Fig. 1. Attenuation of electric field strength by electro-conductive fabric shields

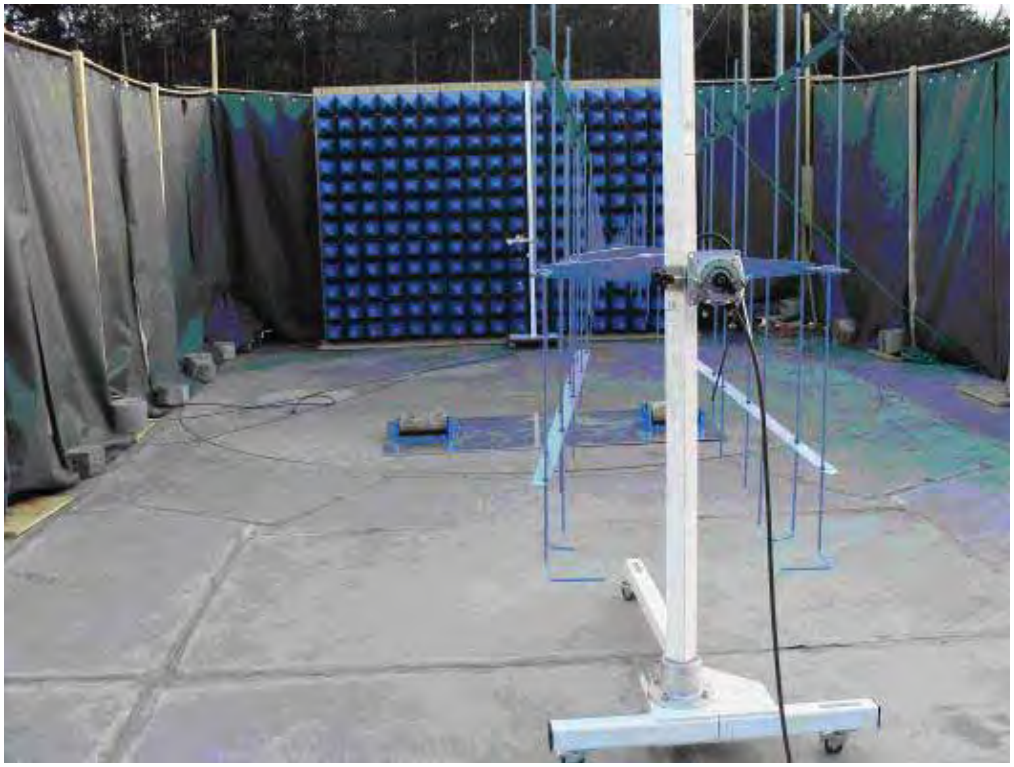

Fig. 2. A view of the model of OAPSTS

4. Method and course of investigations

The tests of the vehicles have been performed in the model of open-area partially shielded test side (OAPSTS). The vehicle immunity to electromagnetic radiation is tested at the electric field strength 30V/m in the reference point (see [6], Fig.1) and for the frequency band 20MHz to 2000MHz. The test should be performed according to the standard ISO 11451-2 [5]. The vehicle should be in an unladen condition (except for necessary test equipment).

The whole frequency band 20MHz – 2000MHz has been divided into the following three frequency intervals: “1” 20MHz - 80MHz, “2” 80MHz –1000MHz and “3” 1000MHz – 2000MHz.

Measurements of the electric field strength have been performed for the following four placements of the attenuating fabric shields and absorbers in OAPSTS (see Fig. 3):

A - three attenuating walls and one absorber at the rear wall,
B - three attenuating walls and one absorber at the rear wall; the object (vehicle) situated at the angle 45^{o},
C - three attenuating walls and one absorber along each wall,
D - three attenuating walls; no absorbers;

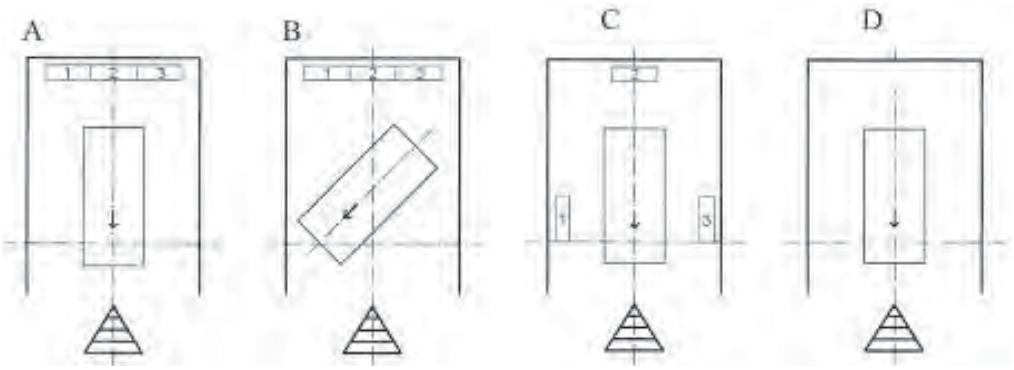

Fig. 3. Model of OAPSTS – Positioning of attenuating walls, absorbers (1,2,3) and a vehicle

The measurement equipment used in the tests was the same as in the tests performed previously in ALSE [6]. The antenna method has been used for generating electromagnetic field. For frequencies in the intervals "1" and "2" EMS HL046 antenna was used and for frequencies in the interval "3" MW Antenna 1-4 was employed. For electric field strength measurements within the limits of OAPSTS the sensor W&G EMR-20 was used, while for the measurements inside the vehicle a miniature isotropic probe was employed. According to ECE UN Regulation No.10 and EU Directive 2004/104/EC recommendations the vehicle under test shall be positioned in front of the antenna while electric field calibration is made, before main test measurements, with the aid of a field sensor which should be positioned in the reference point. The electric field calibration has been performed for vertical and horizontal polarization. The reference point – antenna distance has been fixed and equal 2m.

The tests included the electric field strength measurements inside and outside the model of OAPSTS as well as inside the vehicle. The obtained results are shown in Fig. 4-9.

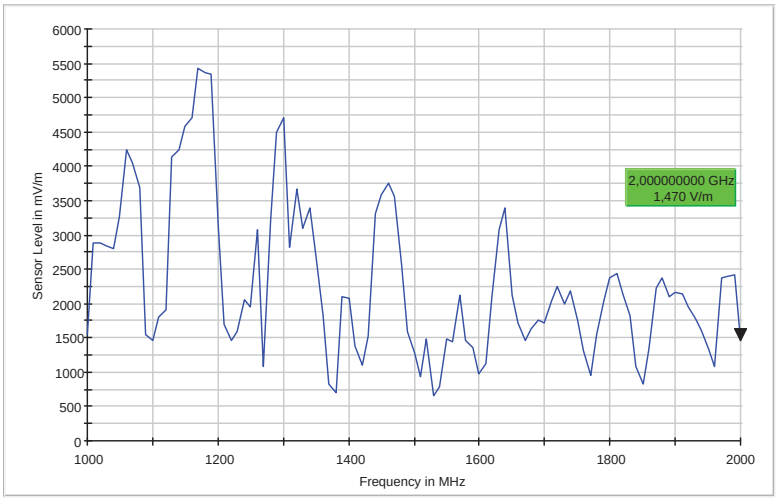

Fig. 4. Electric field strength versus frequency inside the engine chamber of the vehicle Octavia; measurements in open area test site (without shields and absorbers); frequency range "3"

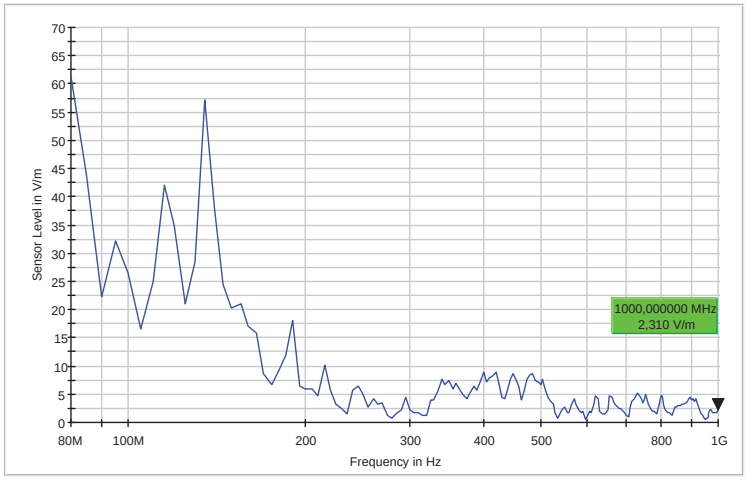

Fig. 5. Electric field strength versus frequency inside the engine chamber of the vehicle Octavia; me asurements for version A of OAPSTS; frequency range "2"

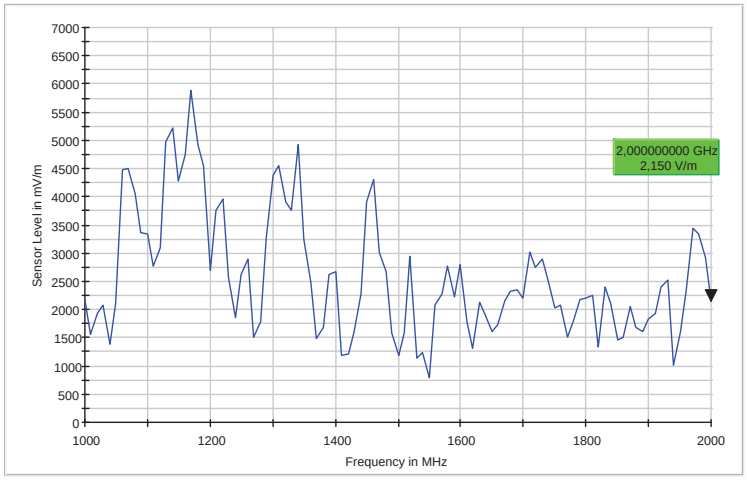

Fig. 6. Electric field strength versus frequency inside the engine chamber of the vehicle Octavia; me asurements for version A of OAPSTS; frequency range "3"

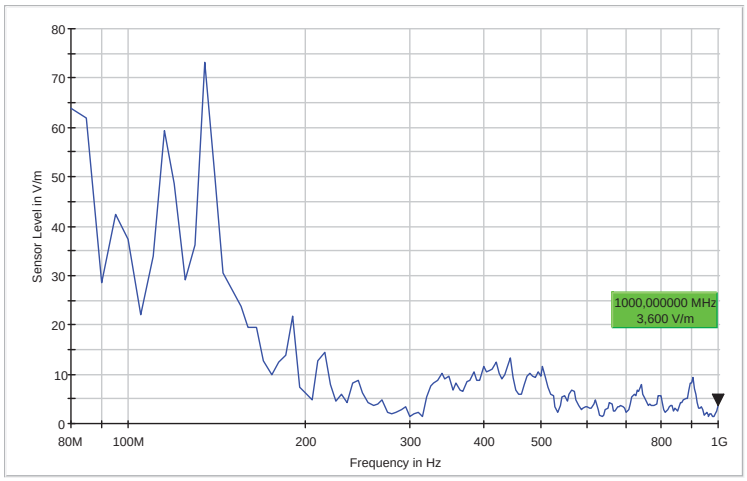

Fig. 7. Electric field strength versus frequency inside the engine chamber of the vehicle Octavia; me asurements for version C of OAPSTS; frequency range "2"

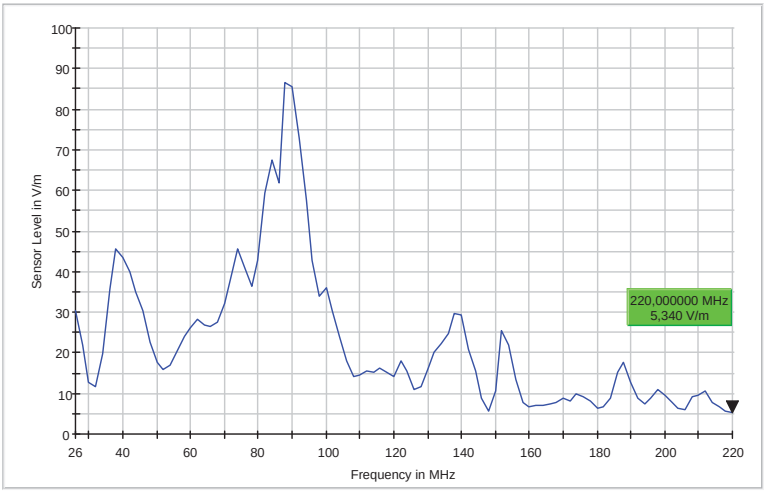

Fig. 8. Electric field strength versus frequency inside the engine chamber of the vehicle Lanos; measurements in open area test site (without shields and absorbers); frequency range "1"

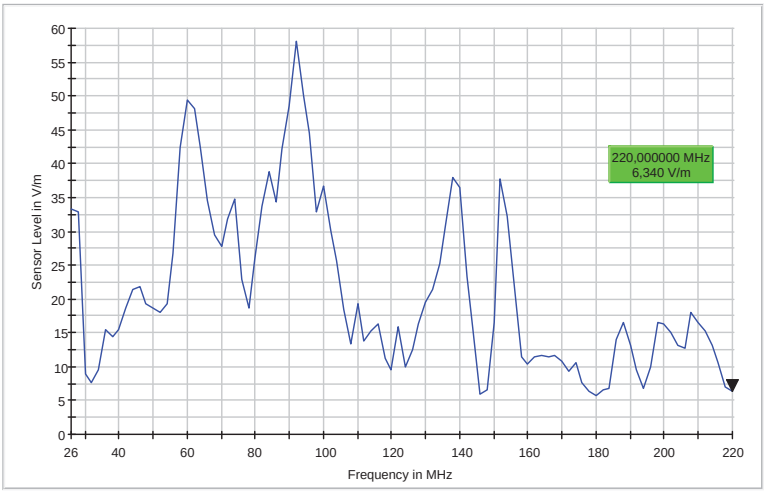

Fig. 9. Electric field strength versus frequency inside the engine chamber of the vehicle Lanos, measurements for version C of OAPSTS; frequency range "1"

A comparative assessment of the OAPSTS model features has been based on statistical estimation. The standard statistical estimators (mean value, mean square value, variance, root mean square value, amplitude) have been calculated on the basis of the characteristics of electric field strength versus frequency. The step of discretization was consistent with recommendations given in EU Directive 2004/104/EU. As the most important estimator the root mean square value of the electric field strength (in relative values) has been admitted. The results of estimation for the root mean square value are shown in Fig. 10. These results show that the best approximation with respect to the open area test site (PO) is obtained for the version A of the OAPSTS model. Somewhat worse results are obtained for the version C.

5. Conclusion

The results of the outlined above investigations indicate that further work concerning working out of open-area partially shielded test sites with almost complete elimination of radiated disturbances to the environment should be continued.

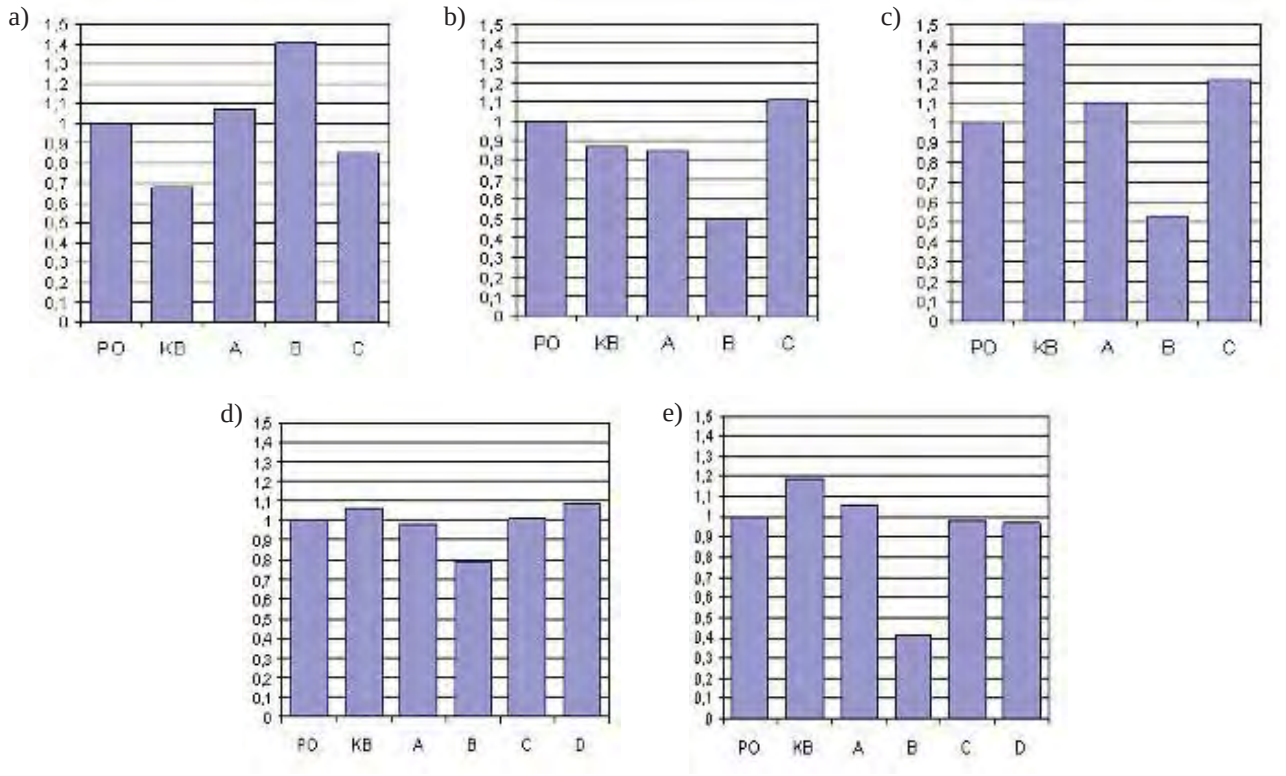

Fig. 10. Root mean square value of electric field strength (in relative values) in the engine chamber for vehicles Octavia and Lanos; PO - open area test site; KB – absorber lined shielding enclosure; A,B,C,D – versions of OAPSTS model; "1", "2", "3" – frequency bands. a) Octavia – band "1", b) Octavia – band "2", c) Octavia – band "3", d) Lanos – band "1", e) Lanos – band "2"

Acknowledgement

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References

[1] *EU Directive 2004/104/EC.*
[2] *ECE UN Regulation No. 10.*
[3] *IEC CISPR 12 – Vehicles, boats and internal combustion engines – radio disturbance characteristics – limits and methods of measurement for the protection of off-board receivers.*
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[5] *ISO 11451-2: 2005 – Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Off-vehicle radiation sources*, 2005.
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