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BSI Standards Publication

Assessment of lighting equipment related to human exposure to electromagnetic fields

Part 1: Results of the EMF measurement campaign from the VDE Test and Certification Institute and ZVEI, the German Electrical and Electronic Manufacturers' Association

National foreword

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Assessment of lighting equipment related to human exposure to electromagnetic fields – Part 1: Results of the EMF measurement campaign from the VDE Test and Certification Institute and ZVEI, the German Electrical and Electronic Manufacturers' Association

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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IEC/TR 62493-1, which is a technical report, has been prepared by IEC technical committee 34: Lamps and related equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
34/178/DTR	34/183/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 62493 series, published under the general title *Assessment of lighting equipment related to human exposure to electromagnetic fields* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

In 2011 it was decided by VDE and ZVEI to start a measurement campaign for testing a broad range of different types of luminaires with different lamp technologies against the new EMF (Electromagnetic Fields) standard IEC 62493:2009 (identical to EN 62493:2010-02). The goal was to get an overview on the EMF measurement results dependent on different lamp technologies used in current luminaires on the market. For this measurement campaign only the test procedure with the so called Van der Hoofden head in the frequency range from 20 kHz to 10 MHz was used.

The goal of this campaign is to identify construction details of lighting equipment which are critical for the EMF measurements.

NOTE The VDE Testing and Certification Institute is a part of the VDE Association for Electrical, Electronic & Information Technologies. The VDE Testing and Certification Institute is accredited on a national and international level for the area of testing and certification of electrotechnical equipment, components and systems. ZVEI is the German Industry Association for the Electrical Industry.

ASSESSMENT OF LIGHTING EQUIPMENT RELATED TO HUMAN EXPOSURE TO ELECTROMAGNETIC FIELDS –

Part 1: Results of the EMF measurement campaign from the VDE Test and Certification Institute and ZVEI, the German Electrical and Electronic Manufacturers' Association

1 Scope

This part of the IEC 62493 series presents an overview on EMF measurement results dependent on different lamp technologies used in current luminaires. For the measurement only the test procedure with the so called Van der Hoofden head in the frequency range from 20 kHz to 10 MHz was used.

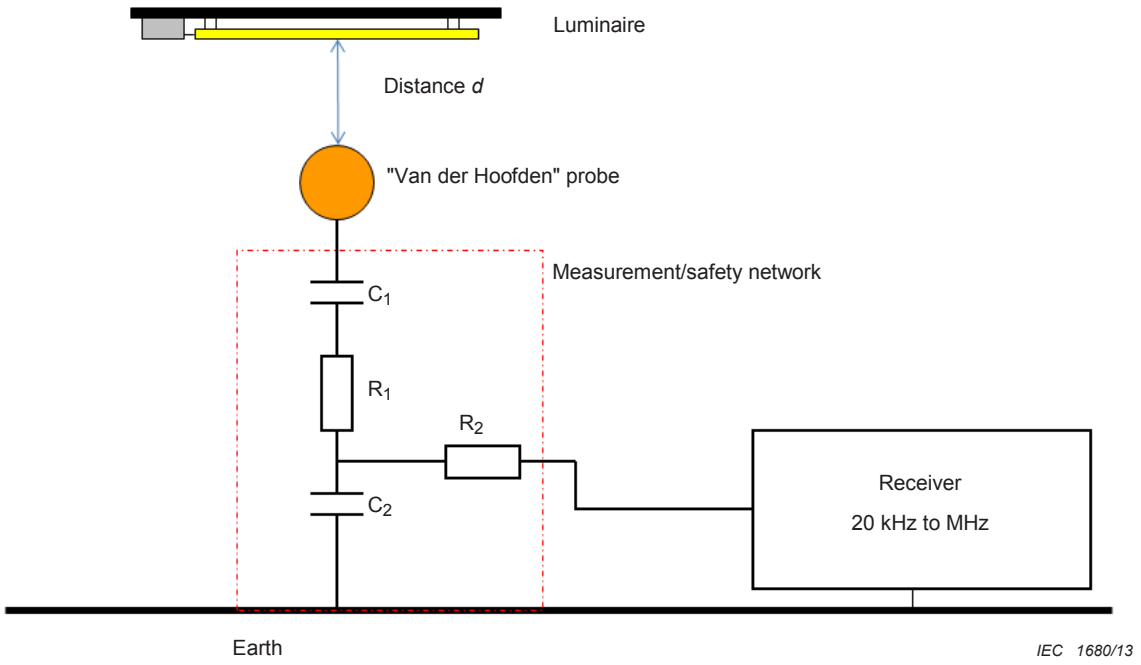
2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62493:2009, *Assessment of lighting equipment related to human exposure to electromagnetic fields*

3 Test procedure

The testing of luminaires has been performed according to the requirements of IEC 62493:2009. The luminaires have been placed over the test head at the distance d as required by the standard. Figure 1 shows the set-up in principal.



Example
C_1 = 470 pF
C_2 = 10 nF
R_1 = 470 Ω
R_2 = 150 Ω

Figure 1 – Measurement set-up according IEC 62493

The result of each measurement over the frequency range from 20 kHz to 10 MHz is a single value *F* which is calculated using all measurement values in the whole frequency range. For this calculation the measured voltages, weighted with the limit at each frequency, are summed up over the whole frequency range. The limit for *F* is a value of 0,85.

The noise level, caused by the thermal noise floor in the receiver is always present even if the luminaire under test is not energized. The value *F* of this noise level in our case is 0,03. The noise level is dependent on the overall noise figure of the receiver and the attenuator setting of the receiver. If the receiver is set to higher attenuations then the noise level is higher and therefore the noise level result *F* is higher also.

4 Presentation of results

4.1 General

In the following subclauses the results of the measurement campaign are presented as tables showing the influence of different parameters of the tested luminaires.

4.2 Frequency distribution of the measured values

The frequency distribution figures show the number of luminaires for which measurement results (Factor *F*) are within a result interval. It is recognized that there is a clustering within some intervals.

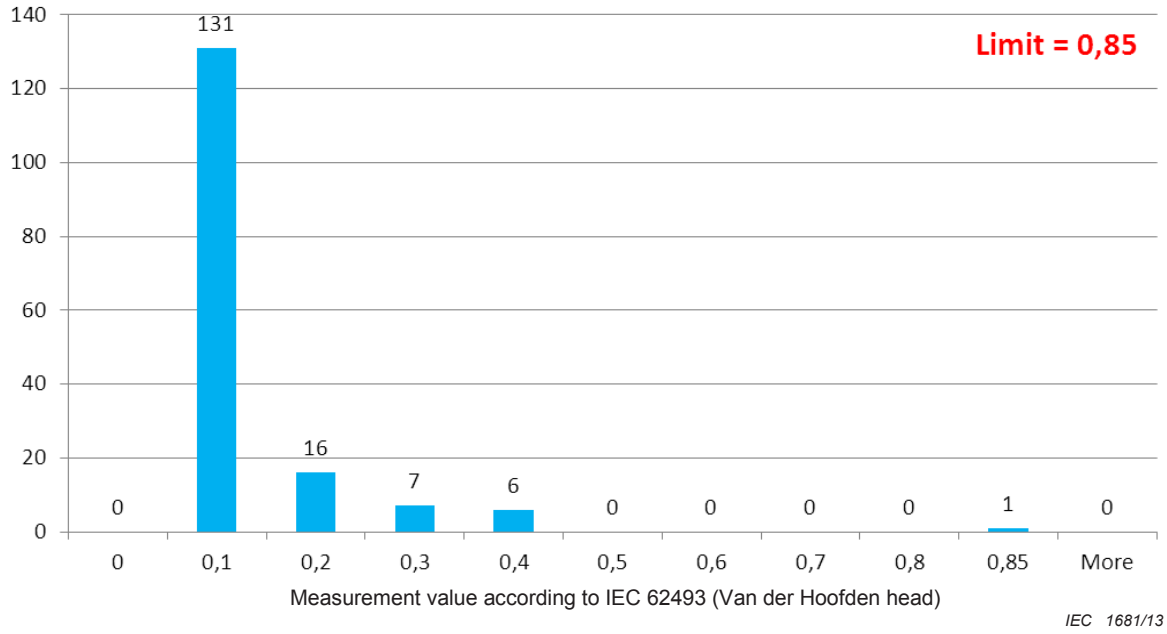


Figure 2 – Frequency distribution of the measured values of the luminaires (absolute number of luminaires)

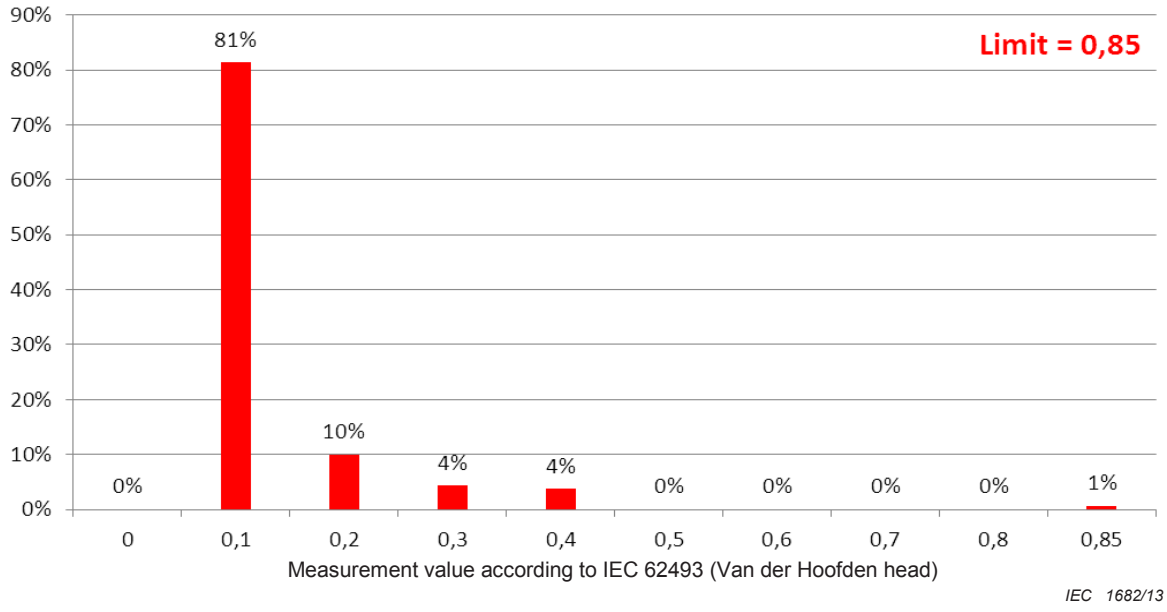


Figure 3 – Frequency distribution of the measured values *F* in the interval from 0 to 0,85 expressed as percentage values.

It is clearly visible in Figure 2 and Figure 3 that a number of 131 luminaires (81 %) out of a total of 161 (= 100 %) generated measurement values between 0 and 0,1. Only 16 luminaires (10 %) are in the range from 0,1 to 0,2. None of the measured luminaires are in the range between 0,4 and 0,85. Only one luminaire has shown a result which is near to the limit of 0,85. It will be explained later why this special luminaire generated such a high result *F*.

A significant majority (99 %) of all measured values are below half (0,425) of the limit (0,85).

In the following Figure 4 the interval from 0 to 0,1 which consists of 131 measured luminaires (80 %) is shown more finely divided. In this diagram the first bar (131 results) of Figure 2 above is shown more finely divided.

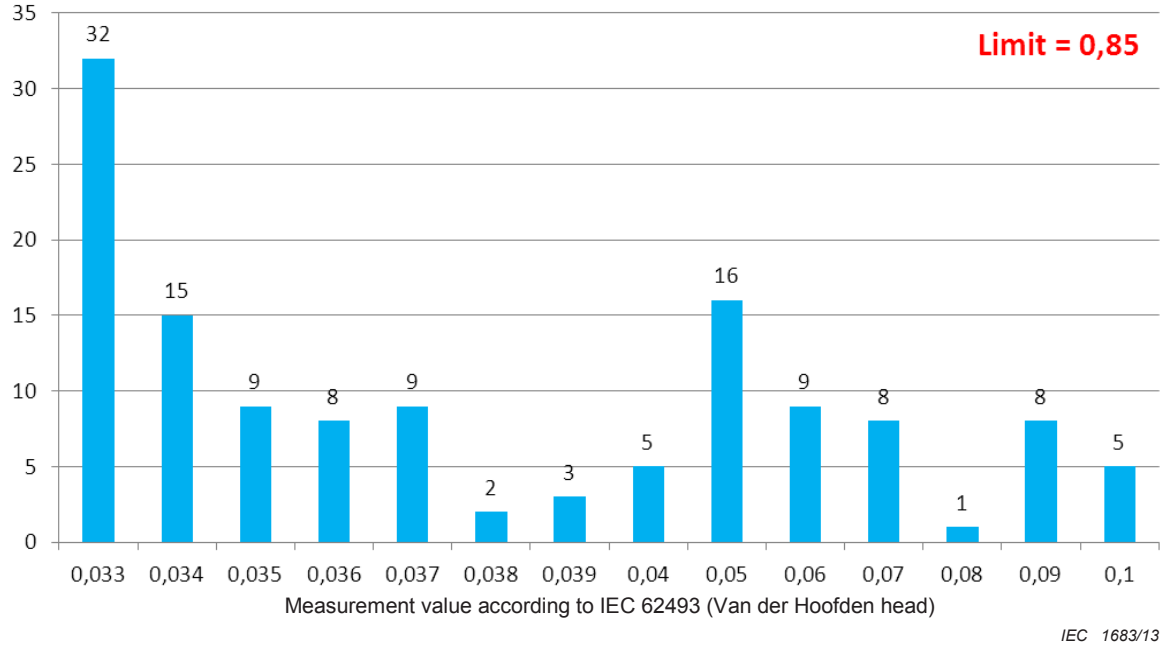
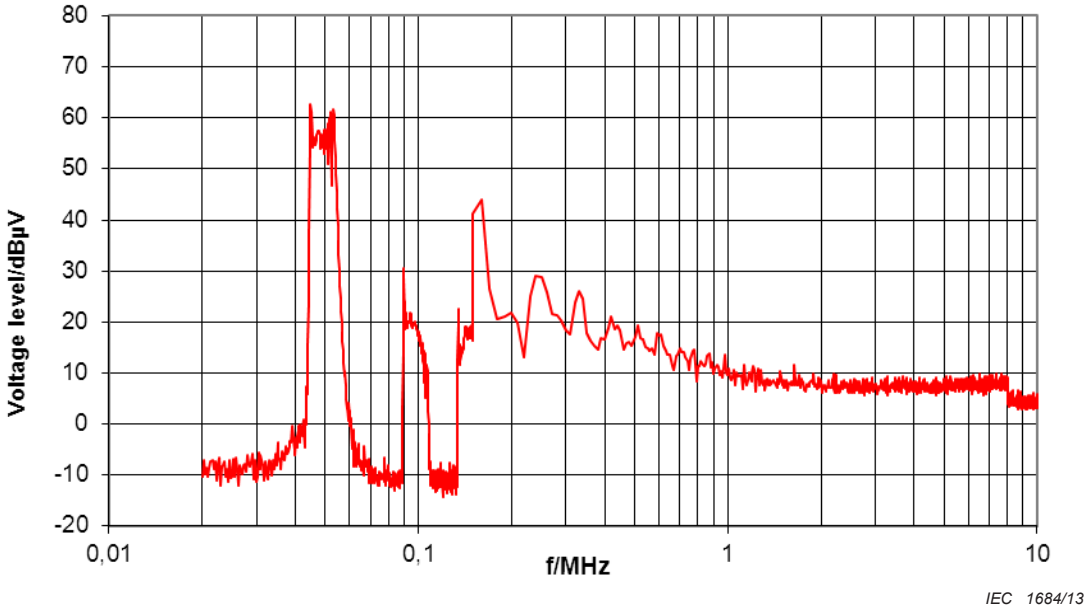


Figure 4 – Frequency distribution of the measured values *F* in the interval from 0 to 0,1.

The largest number of samples (32 pieces) corresponds to the noise level of approximately 0,03. So the 32 samples out of 161 samples in total have emissions which are below 0,035 % of the applicable limit (0,85).

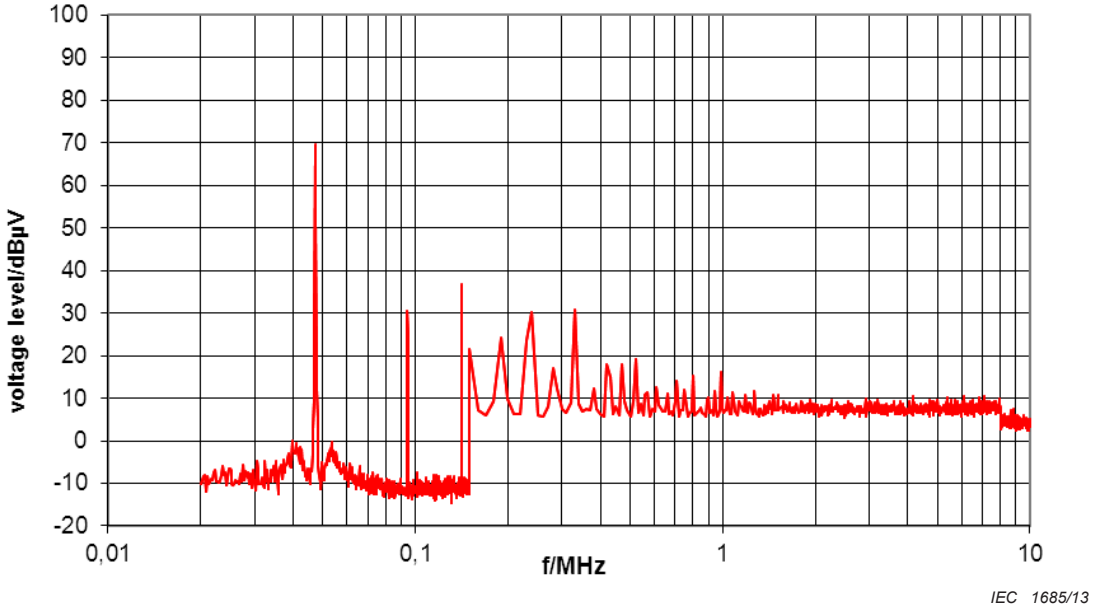
4.3 Explanation for the high measurement results of one single luminaire

The highest value measured during the campaign was a factor *F* = 0,84. This factor was measured with a luminaire equipped with a 58 W T8 lamp which was covered by a thin, transparent plastic protection. Only if the luminaire is supplied with 230 V AC, the high value of 0,84 was measured. Supplied with 230 V DC the measured value was only *F* = 0,13. The reason for this behavior is the frequency modulation of the operating frequency of the electronic control gear due to the 50 Hz (100 Hz) supply voltage modulation. This leads to a kind of “smearing” of the spectrum, clearly visible in Figure 5 compared to the spectrum in DC mode in Figure 6 which is a stable line spectrum.



NOTE Voltage at the output of the Van der Hoofden head, measured with the receiver.

Figure 5 – Luminaire supplied with AC mains power 230 V / 50 Hz.



NOTE Voltage at the output of the Van der Hoofden head, measured with the receiver.

Figure 6 – Same luminaire as presented in Figure 5 supplied with DC mains power 230 V / 0 Hz.

The “smearing” of the spectrum leads to a higher factor *F* since the factor *F* is calculated by summation of the weighted voltage levels measured with the receiver. It is obvious that the electric field generated by the luminaire is nearly identical in AC and DC mode, only the frequency modulation, the measurement with the receiver at different time points for different frequencies and the summation rule are leading to the huge difference in the result. The spectrum of the lamp is always similar to the DC mode, but the frequency is shifted with the modulation frequency (typical 100 Hz). The measurement method with the receiver leads to the higher results in AC mode.

A change in the measurement procedure in IEC 64293 is needed to avoid this misinterpretation. The activities to resolve this problem in IEC 62493 have been started.

4.4 Evaluation of the influence of certain characteristics of the luminaires

The following evaluations show the influence on the EMF results measured according IEC 62493 resulting from specific characteristics of the luminaires. Examples of the characteristics are shape, lamp type used, power consumption. The goal of this evaluation is to identify construction details of luminaires which are critical for the EMF measurements. All tables are sorted for the average of the measured results (highest average measurement value is on top). Here average means that this is the average of the results of all measured luminaires with the same specification.

To avoid any deviation caused by the single critical luminaire that showed a huge difference between AC and DC mode, only the DC results of this luminaire have been used in the tables below.

In all tables, the columns are structured in the same way as shown in Table 1.

Table 1 – Structure of tables

Column	Description
First column	Parameter which is varied. This can be the type of the luminaire or some characteristics (e.g. material, lamp technology, lamp cover, type of lamp)
Number of samples	This column gives the absolute number of samples which have the characteristic given in the first column.
Average value	This is the linear average of the measured results (factor *F* according IEC 62493) during the investigations. All values in the tables are sorted in descending order using the values of this column.
Max value	This gives the maximum value of all measured results (factor *F* according IEC 62493) in the group of samples.

4.5 Type of luminaires according Table A.1 of IEC 62493:2009

Table A.1 of IEC 62493:2009 determines the distance to the test head which is required for measurement.

The row with the number (23) in Table 2 is used mostly for luminaires with LED lamps which are intended for ceiling and recessed mounting. The standard in its present edition often refers mostly to luminaires with fluorescent lamps in Table A.1 of IEC 62493:2009. Therefore luminaires with LED are mostly in this row.

Table 2 – Measurement results of luminaire types in accordance with Table A.1 of IEC 62493:2009

Type of lighting equipment according to Table A.1 of IEC 62493:2009	Measurement distance [cm]	Number of samples	Measurement results (Factor *F*)	
			Average value	Max value
Ceiling and/or recessed lighting equipment for fluorescent lamps with an input power ≤ 180 W (6)	50	65	0,11	0,38
Table lighting equipment (2)	30	7	0,07	0,21
Other lighting equipment not mentioned in Table A.1 of IEC 62493:2009 (23)	50	25	0,06	0,25
Ceiling and/or recessed lighting equipment for fluorescent lamps with an input power > 180 W (7)	70	3	0,06	0,08
Wall lighting equipment (3)	50	16	0,05	0,12
Ground recessed lighting equipment (17)	50	1	0,04	0,04
Suspended lighting equipment (5)	50	11	0,04	0,05
Ceiling and/or recessed lighting equipment for discharge lamps with an input power ≤ 180 W (8)	70	11	0,04	0,04
Lighting equipment for road and street lighting (12)	200	18	0,03	0,04
Hand lamps (1)	5	1	0,03	0,03
Ceiling and/or recessed lighting equipment for discharge lamps with an input power > 180 W (9)	100	2	0,03	0,03
Flood lights (11)	200	1	0,03	0,03
The number in brackets () represents the position in Table A.1 of IEC 62493:2009.				

There was no clear result visible in the table. It is therefore not possible to derive further conclusions regarding the EMF behaviour from this result and from the luminaire classification in IEC 62493:2009, Table A.1.

4.6 Lamp cover

The influence of the lamp cover (luminaire construction: housing and different reflector material) is shown in Table 3.

Table 3 – Measurement results dependent on the lamp cover

Lamp cover	Measurement results (Factor *F*)		
	Number of samples	Average value	Max value
Plastic	69	0,10	0,38
None	39	0,08	0,27
Glass	34	0,04	0,10
Mirror reflector	10	0,04	0,05
Metal reflector	9	0,04	0,05

It can be clearly seen that if no conductive cover is over the lamp (e.g. no reflector or only a transparent plastic cover) the highest values (highest average value and highest max value) will be measured.

4.7 Type of lamp

Table 4 gives an overview of the measurement results dependent on the lamp technology used (lamp types).

Table 4 – Measurement dependent on the lamp technology used

Type of lamp	Measurement results (Factor *F*)		
	Samples	Average values	Max values
T8	23	0,15	0,38
TC-S/E	2	0,15	0,21
TC-T	6	0,10	0,19
T5	34	0,09	0,36
TC-F	2	0,09	0,15
T5 circular	3	0,08	0,16
TC-L	2	0,06	0,09
LED	42	0,05	0,25
Halogen	6	0,04	0,05
Energy saving lamp	1	0,04	0,04
HID	18	0,04	0,06
TC-T + T 16 R	2	0,04	0,04
TC-D	5	0,03	0,04
QL	2	0,03	0,04
NAV	7	0,03	0,04
T 16 R	1	0,03	0,03
CPO-TW	4	0,03	0,03
SDWT	1	0,03	0,03

The lamp type T8 (fluorescent) shows the highest average values and the highest max values. The lamp type T5 follows with the next max values.

It is interesting to see that all samples with LED lamps (42 samples!) are showing low measurement results which are less than 30 % of the limit (max values).

4.8 Protection class

The measurement results dependent on the different luminaire protection classes are shown in Table 5.

Table 5 – Measurement results dependent on the luminaire protection classes

Protection class (I, II or III)	Measurement results (Factor *F*)		
	Number of samples	Average values	Max values
II	39	0,09	0,38
I	118	0,07	0,32
Battery	1	0,03	0,03
FE	2	0,03	0,03

It is recognizable that the protection class II (without protective earth) is more critical regarding EMF. Also the highest measurement value ever measured in this campaign was a class II luminaire.

4.9 Outer shape of the luminaire

Table 6 gives an overview of the measurement results in relation to the dimension (outer shape) of the luminaire housing.

Table 6 – Measurement results dependent on the outer luminaire shape

Outer shape of the luminaire	Measurement results (Factor *F*)		
	Number of samples	Average values	Max values
Elongated	65	0,11	0,38
Square	7	0,07	0,25
Circular	51	0,05	0,19
Combination [a]	2	0,05	0,05
Box-shaped	24	0,04	0,12
Hand-held	1	0,03	0,03
Oval	11	0,03	0,04
[a] Independent control gear with lamps (e. g. halogen or LED for ceiling mounting)			

The elongated shape of the luminaire is clearly the most critical with respect to the limits. All other shapes are much lower. The reason might be that the longer fluorescent lamps need higher operation voltages and are therefore generating higher electric fields.

4.10 Total rated power of all lamps in a luminaire

The evaluation of the measurement results regarding the total lamp power used in the luminaire has been done in Table 7.

Table 7 – Measurement results dependent on the total lamp power in a luminiare

Total lamp power in the luminaire [Watt]	Measurement results (Factor *F*)		
	Number of samples	Average values	Max values
100 to120	27	0,12	0,38
20 to 40	28	0,09	0,36
80 to 100	13	0,07	0,20
0 to 20	21	0,06	0,26
160 to 180	5	0,06	0,11
40 to 60	26	0,06	0,22
60 to 80	29	0,06	0,19
180 to 200	1	0,05	0,05
320 to 340	1	0,04	0,04
240 to 260	1	0,03	0,03
140 to 160	6	0,03	0,04
380 to 400	2	0,03	0,03
120 to 140	1	0,03	0,03

It can be deducted that the EMF measurement result seems to be more or less independent from the total power of all lamps in the luminaire. High power does not necessarily mean a high measurement result. The cause might be that high power usually means larger distance according to Table A.1 of IEC 62493:2009. An example might be a street lighting with an HID

lamp and high power. The measurement distance is 2 m since such luminaires are usually not built for normal living rooms.

4.11 Material of the enclosure

The influence of the housing material of the luminaire on the measurement results is shown in Table 8.

Table 8 – Measurement results dependent on the material of the luminaire housing

Material of the enclosure	Measurement results (Factor *F*)		
	Number of samples	Average values	Max values
Plastic	22	0,14	0,38
Independent set-up (no enclosure) [a]	6	0,09	0,19
Wood	3	0,07	0,12
Metal	122	0,06	0,36
None	8	0,06	0,07
[a] Mostly an LED light source radiating with no cover or enclosure (e.g. flush mount).			

It can be seen that the metal enclosure is less critical than a plastic enclosure. However, in metal enclosures some luminaires are showing higher max values.

5 Conclusion

The measurement results show that out of 161 measured luminaires with different lamp technologies no luminaire was over the limit 0,85. A high percentage, 99 % of luminaires (see 4.2) are under half the limit (limit 0,85 / 2 = 0,425). The investigation shows clearly that present luminaires with present lamp technologies are not critical at all regarding EMF. It has been shown that based on certain construction details of the luminaire (e.g. LED lamps) it is very likely (close to 100 %) that such a luminaire will pass the test with the Van der Hoofden head according to IEC 62493. The standardisation committees might take this into account during maintenance of the IEC 62493.

For manufacturers of luminaires it is therefore possible to do a measurement on one type of a series of luminaires and then transfer these results to the other types in a similar series without measurement. If the same lamp technology and similar shapes and materials are used it is very unlikely that one of the luminaires of the series will not pass an EMF test according IEC 62493 with the test head. The huge margin to the limit allows such an assumption.

Based on the results for most luminaires it will not be necessary for the manufacturers to change anything in the construction regarding EMF.

It is expected that the trend in the lamp technology towards LED, as light source, will additionally lead to a less critical behaviour regarding EMF. The average measurement value of all 42 luminaires with LED light source is only 0,05 (< 0,1 % of the limit! See Table 4).

A solution for the “frequency modulation problem” as explained in 4.3 is needed and activities to improve the measurement procedure in IEC 62493 have started.

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