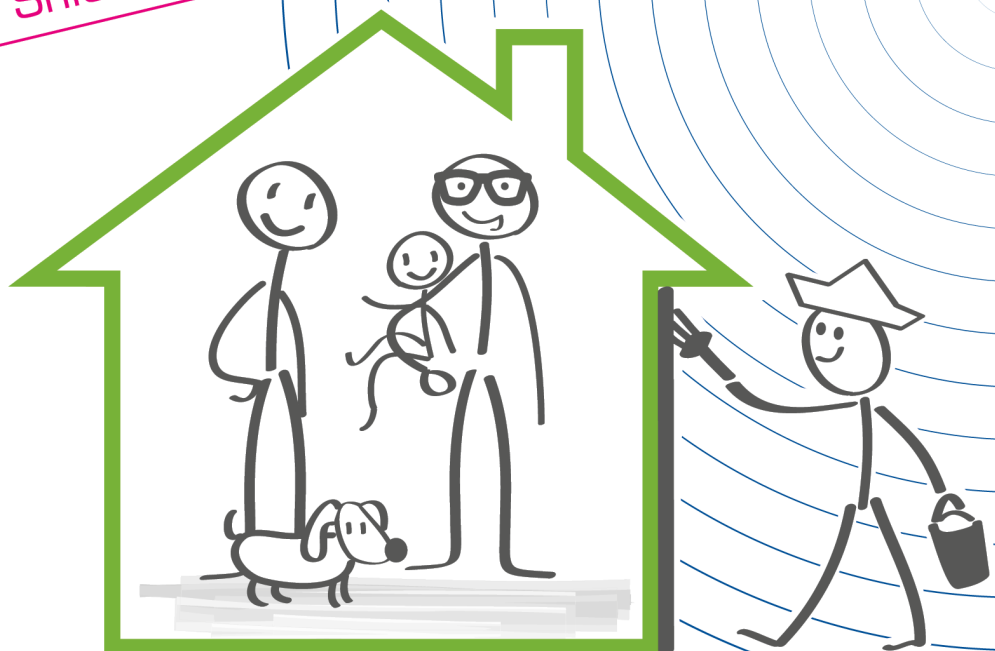


**VDB EMC Guides**  
ElectroMagnetic Compatibility

**Reducing  
Radio Frequency Radiation  
in the Built Environment:  
Building and  
Shielding Materials**

Author: Dietrich Moldan

1<sup>st</sup> Update 2022  
Shielding Paints



Fifth Volume of the Series “VDB EMC Guides”

**Reducing Radio Frequency Radiation in the Built Environment: Building and Shielding Materials  
1<sup>st</sup> Update 2022: Shielding Paints**

**Author:**

Dr.-Ing. Dietrich Moldan

**Translation:**

Katharina Gustavs

**Publisher:**

German Association of Building Biology Professionals VDB e.V.

Roggenkamp 21

21266 Jesteburg

Germany

[www.baubiologie.net](http://www.baubiologie.net)

**Editor, layout, and design:**

Dr.-Ing. Martin H. Virnich

**Cover design:**

Harald Hans Vogel

**Distribution:**

Dr. Moldan Umweltanalytik, Iphofen and

German Association of Building Biology Professionals VDB e.V., Jesteburg

All rights reserved. This work and all parts thereof are protected by copyright. Any use outside the narrow limits of copyright law without the written consent of the publisher or author is not permitted and may be punishable by law. This applies especially to copying, translating, microfilming, as well as storage and processing in electronic systems.

Author, editor, and publisher have written this work to the best of their knowledge and with great care for accuracy. However, contents-related and technical errors cannot be completely ruled out. Orthographic rules have been chosen by the author. The author is responsible for the content of this work as well as the correct and complete use of citations.

© May 2022 VDB e.V., Jesteburg

Digital Edition

**Published in-house by VDB e.V.**

Roggenkamp 21

21266 Jesteburg

Germany

**ISBN 978-3-948407-16-2**

---

## Table of contents

1	Introduction .....	3
2	Shielding or exposure reduction? .....	3
3	RF measurements to evaluate the shielding effectiveness on site .....	5
3.1	Broadband RF meter .....	5
3.2	RF spectrum analyzer .....	5
4	Purchase of shielding paint test samples .....	6
5	Obtainment of manufacturer information .....	6
6	Material testing .....	6
7	Overview of tested products .....	7
8	Container, material type, batch number, and best before date .....	8
9	VOC content .....	9
10	Preparation of test samples .....	10
11	Testing of adhesive tensile strength .....	11
12	Grounding accessories .....	12
12.1	Personal and property protection .....	12
12.2	Spread of ELF electric fields .....	13
13	Standard wall paints applied to shielding paints .....	14
14	Price comparison .....	15
15	Measurement results of transmission attenuation of 19 samples .....	15
16	References and links .....	19

## 1 Introduction

The 4<sup>th</sup> volume of the series “VDB EMC Guides – Electromagnetic Compatibility” with the title “Reducing Radio Frequency Radiation in the Built Environment: Building and Shielding Materials” by the authors Peter Pauli and Dietrich Moldan was published as the third edition in 2015 [i].

The two authors started publishing data on the shielding effectiveness of building and shielding materials under the same title in 2000 and 2003 (self-published by Dr. Moldan) and continued with three additional publications on behalf of the Bavarian Environment Agency (LfU) between 2002 and 2008. Today it is the de facto standard on the subject matter in German-speaking countries and beyond. It also has become the reference of choice for building biology testing specialists, architects, consultants, electricians, and builders. Since 1998 several hundred measurements of building and shielding materials have been carried out by the authors on behalf of manufacturers or the authors purchased commercially available products themselves. In the above-mentioned publications, the authors then included the products of general interest. The frequency range tested extends from 300 MHz to 10 GHz.

For the first time, the newly emerging mobile communication generation 5G New Radio (NR) will be using frequencies above 20 GHz (frequency range 2 (FR2) extends from 24.25 GHz to 86 GHz), which is why information on the shielding effectiveness in this higher frequency band is of great interest. The co-author Dr. Dietrich Moldan therefore gave a presentation on this topic at the 10<sup>th</sup> EMC Conference “Power Supply and Wireless Communication Technologies” of the German Association of Building Biology Professionals e.V. (VDB) in May 2019, which is included in the VDB Conference CD [ii]. The measurement results of the radio frequency shielding effectiveness of 26 representative building and shielding materials are documented on this CD. These measurements, which were done specifically for the conference, cover the frequency range from 24 GHz to 40 GHz.

Since 2015 a great deal of change has occurred, especially in the product group of shielding paints. The number of suppliers and products has increased, but quality varies greatly.

We regularly receive questions asking if a particular shielding paint has already been tested and what to make of manufacturers’ advertising claims, which often sound too good to be true. It has also been pointed out that only a few manufacturers provide information on the correct grounding of their products and offer appropriate grounding accessories.

As Prof. Peter Pauli has retired a few years ago, the co-author Dr. Dietrich Moldan has decided to create and publish relevant updates for the product group of radio frequency shielding paints.

The present documentation is by no means exhaustive, but it will continue to be amended and updated as needed.

## 2 Shielding or exposure reduction?

First a few words on the definition and use of shielding paints.

All commercially available shielding materials – paints, plasters, wallpapers, window films, foils, etc. – do not “shield” or block 100% of the wireless radiation, but always just “reduce radio frequency radiation” by a certain factor. It is therefore certainly possible that a mobile phone/smartphone still has reception inside a “shielded” room; however, with the unpleasant, though logical, consequence that the device now needs to overcome a higher shielding barrier and thus must use more power – directly next to the user’s body.

The bar display on a mobile phone that indicates signal strength is solely for the user’s information as to whether reception is good or hardly possible. All 5 bars can already be displayed at a power density of 1  $\mu\text{W}/\text{m}^2$  (equivalent to 19.4 mV/m). The bars will not change, even if the incoming radiation level

from cell sites is, for example, a thousand or a million times higher at  $1 \text{ mW/m}^2$  ( $613.5 \text{ mV/m}$ ) or  $1 \text{ W/m}^2$  ( $19.4 \text{ V/m}$ ). It follows that a standard mobile phone cannot be used as a “measuring device.”

Another common error: The bars displayed provide information on the reception quality at a given location. The displayed reception quality, however, is only valid for the respective provider, whose SIM card is used in the mobile phone. Other providers, who may provide a much higher field strength at the point of reception, cannot be detected by the mobile phone. Insofar it is not possible to make any statement on the actual radio frequency exposure level.

Oftentimes shielding effectiveness is shown in decibel (dB). If a shielding product shows, for example, a shielding effectiveness of 30 dB, this means:

- ▶ The transmission (penetration) of radio frequency radiation is attenuated by 30 dB.
- ▶ This is equivalent to a reduction in power density by a factor of 1000 between the front of the product and the back of the product (shielded side).
- ▶ A power density of  $1/1000 = 0.1\%$  passes through the shielding material and thus the radio frequency radiation exposure is reduced by 99.9%.

Note that the attenuation of the field strength is equivalent to the root of the attenuation of the power density, as field strength and power density share a quadratic relationship. However, the decibel specifications for the attenuation of both field strength and power density are the same. Details regarding this relationship are described in [i], Chapter 12.

Two aspects are always crucial for RF exposure levels (power density, field strength) behind the shielding:

- ▶ The RF exposure level in front of the shielding
- ▶ The RF attenuation of the shielding material at a particular frequency.

At various exposure levels, the assumed attenuation of 30 dB above translates into the following levels of shielding effectiveness in Table 1:

Power Density		Field Strength	
Exposure <u>in front of</u> shielding	Exposure <u>behind</u> shielding	Exposure <u>in front of</u> shielding	Exposure <u>behind</u> shielding
10,000 $\mu\text{W/m}^2$	10 $\mu\text{W/m}^2$	1,941 mV/m	61.4 mV/m
1,000 $\mu\text{W/m}^2$	1 $\mu\text{W/m}^2$	614 mV/m	19.4 mV/m
100 $\mu\text{W/m}^2$	0.1 $\mu\text{W/m}^2$	194 mV/m	6.14 mV/m
10 $\mu\text{W/m}^2$	0.01 $\mu\text{W/m}^2$	61 mV/m	1.94 mV/m

**Table 1: Selected levels of power density and field strength at an attenuation of 30 dB**

It is easy to understand that the RF attenuation inside a building cannot be higher than the RF attenuation determined under perfect lab conditions. In fact, lab values need to be significantly higher than the target attenuation of a particular project. A shielding effectiveness of 30 dB or higher already requires special – and accordingly more expensive – shielding materials, installation techniques, and knowledge on how to install shielding in rooms – even if laboratory attenuation levels of the used materials are already at 40 dB, 50 dB, or even higher. For attenuation levels above 30 dB, installers of shielding materials must be very careful and must have the appropriate know-how.

It is therefore realistic to reach a shielding effectiveness of about 20 dB for the typical mobile network frequencies between 1 GHz and 3 GHz by following standard practices.

It is important to note that radio frequency radiation generally not only passes through walls, but also through ceilings, floors, doors, window glazing, window frames and casements. Reflections of incident radiation in the surrounding area can also play a significant role.

In view of the above facts, the product claims of some manufacturers with especially high attenuation levels of 60 dB up to 120 dB are questionable.

### **3 RF measurements to evaluate the shielding effectiveness on site**

The type of RF meter used to verify the shielding effectiveness in a given room is crucial for the evaluation. RF meters with directionality, such as directional antennas (e.g. log-per or logarithmic periodic antennas) as well as non-visible antennas integrated into a device, can only measure RF exposure levels from a preferred direction unlike meters with omnidirectional antennas, which measure in one plane (2D), such as rod, dipole, and biconical antennas. The latter antennas do not only record the radiation from a preferred direction but from all directions on a polarization plane (whereby the person taking the measurements must be careful not to shadow the radio signal with their own body). In a first step, this translates into a significant simplification of the measurements; other levels of incident radiation also need to be considered: horizontal through vertical. As a result, the antenna needs to be moved and waved through the different planes of polarization in a given room. Furthermore, a certain room volume needs to be scanned by this “method of waving in all directions” because reflections and resulting interferences always form standing waves that can lead to strong differences in exposure levels within short distances. The maximum or peak hold value of the standing waves is then used for evaluation.

Once you are familiar with this issue, the next question arises: Will a broadband RF meter do or is an RF spectrum analyzer needed?

#### **3.1 Broadband RF meter**

Exploratory measurements can be carried out with a broadband RF meter for all frequencies for which the particular meter is specified, including any separate antennas, which can be used with the meter. However, the power output of mobile communication base stations is not constant but fluctuates constantly, which is a well-known fact. Therefore, exposure levels also fluctuate constantly, complicating the comparison of measurements taken at different times, even if time intervals are only short. Nevertheless, this method can be useful in obtaining an initial rough assessment of the situation and serving as a guide during shielding mockup tests.

#### **3.2 RF spectrum analyzer**

An RF spectrum analyzer, of course, can provide significantly more reliable and reproducible measurement results for RF exposure levels. Independent of the time of measurement, this instrument can detect the minimum transmission power of mobile networks – including GSM (2G) and WCDMA/UMTS (3G) (already shut down in some countries) as well as LTE (4G) and 5G frequencies below 3 GHz – that is generated by configuration, pilot, and control channels at constant power. Based on the minimum transmission power, it is possible to calculate the exposure level at maximum load of the mobile communication base station. The actual exposure level (as can be detected with a broadband RF meter) fluctuates constantly and unpredictably between minimum and maximum.

The comparison of measurements before and after applying a shielding paint or installing a shielding material at a significantly later date is generally plagued with uncertainties when using a broadband RF meter. Besides the above-mentioned fluctuations of transmission power, the main beam direction of the base station antennas could have changed in the meantime or additional antennas could have been installed in the surrounding area.

On the other hand, if measurements of exposure levels before and after the installation of shielding materials are taken with an RF spectrum analyzer, the measurement results can be very reliable.

## 4 Purchase of shielding paint test samples

In October 2021, 20 different products of 16 different manufacturers or suppliers were bought anonymously in Europe and the US.

The first round of extensive testing took place at the end of November 2021. This has been complemented by further testing.

## 5 Obtainment of manufacturer information

Besides the actual test regarding the shielding effectiveness against radio frequency radiation, additional data have been collected for all products.

- ▶ Manufacturer
- ▶ Product name
- ▶ Sample size
- ▶ Type of material
- ▶ Batch number
- ▶ Best before date
- ▶ VOC content according to manufacturer (volatile organic compounds, such as solvents)
- ▶ Yield (m<sup>2</sup>/l) according to data sheet
- ▶ Frequency-dependent RF attenuation according to the manufacturer, possibly for different coats of thickness or several coats.

The product information provided by the manufacturers or suppliers online was considered in this evaluation.

## 6 Material testing

In an EMC chamber, the shielding effectiveness / transmission attenuation of the products was measured across the frequency range from 600 MHz to 40 GHz with two network vector analyzers (600 MHz – 10 GHz and 10 GHz – 40 GHz).

The samples were created by applying one or two coats of paint to a piece of hardboard (which has no shielding effectiveness of its own) according to manufacturer specifications, using the maximum amount of paint per square meter, which translates into the highest attenuation and the lowest yield in m<sup>2</sup>/l.

Additionally, all products were tested for their attenuation effectiveness with a standardized coat of 6 m<sup>2</sup>/l. This allows for a direct comparison between the different products regarding their attenuation properties.

Once they are dry, shielding paints usually have a topcoat applied. For the first time, we also tested to what extent the shielding effectiveness remains the same or changes after two coats of standard interior emulsion paint were applied.

Since it is possible to cover shielding paint with additional layers (e.g. wallpaper), the adhesive tensile strength was also tested.

Note:

The measurement results in this publication can differ from the ones in the edition from 2015, as various manufacturers have changed their formulas in the meantime.

## 7 Overview of tested products

The following 19 products have been tested:

Manufacturer/supplier	Product name	Country
Adoral	Anti Radiation Paint EWIFI	ESP
AegisGuard	AegisGuard LP (Additive)	USA
AURO	Safe Shield Nr. 332	GER
Biologa DANELL	HF-Abschirmfarbe HF65	GER
BlocPaint	EMF/WiFi/RF Blocking Paint	GBR
Compra Pintura	Proshield Premium	ESP
ECOS PAINTS	EMR/EMF Shielding Paint	USA
emf-protect	emfturtal Abschirmfarbe PLV (Powder)	GER
GEOVITAL	Abschirmfarbe T98	AUT
Gigahertz Solutions	Abschirmfarbe CFA40	GER
Graphenstone	PROSHIELD Premium	ESP
PEN-YANG	Biologische Farb- und Putzbehandlung (Additive)	GER
Rustins	G Shield Electro Smog Shielding Paint	GBR
STO	eProtect Color	SUI
Stop Straling	Stop Straling	NED
YSHIELD	Abschirmfarbe HSF54	GER
YSHIELD	Abschirmfarbe MAX54	GER
YSHIELD	Abschirmfarbe DRY54 (Powder)	GER
YSHIELD	Abschirmfarbe HSF64	GER

Abschirmfarbe = Shielding Paint

Table 2: Overview of manufacturers/suppliers and tested products



Figure 1:  
“Group photo” of shielding paints tested and additives for standard paints



Figure 2:  
Shielding paint shades after one coat. The two white bars come from a white wall paint with special shielding additives: *AegisGuard LP* and *PEN-YANG Biologische Farb- und Putzbehandlung* (fine quartz powder)



## 8 Container, material type, batch number, and best before date

Some manufacturers/suppliers sell their products in only one package size. Most of them, however, have two different container sizes. For testing, the smaller-size containers or packages have been bought, as shown in Table 3.

The batch number on the container is of fundamental importance for tracing a possibly defective product and as part of a proper quality management system. About half of all suppliers do not disclose a batch number on their products. Insofar it is impossible to inquire about the age of any of those products.

A few manufacturers indicate a batch number or production date, others the best before date (BBD), which is more useful for the end user.

A batch number or production date is only useful for the user in case of a complaint. The manufacturer can then trace a possible retained sample of the same batch or make a statement on the shelf life of their product. If the best before date is missing, a user cannot know if the product is already out of date at the time of purchase or how long it will still last under normal conditions.

The container size of the Anti-Radiation Paint EWIFI by *Adoral* is given with 14 liters on its website; however, it contains only 12 liters according to the label on the container.

Manufacturer/Supplier	Product name	Container Size	Material	Batch number	BBD
Adoral	Anti Radiation Paint EWIFI	12 l	Liquid	Yes	No
AegisGuard	AegisGuard LP (Additive)	4 FL OZ (118 ml)	Liquid	No	No
AURO	Safe Shield Nr. 332	1 l	Liquid	Yes	No
Biologa DANELL	HF-Abschirmfarbe HF65	1 l	Liquid	Yes	Yes
BlocPaint	EMF/WiFi/RF Blocking Paint	1 l	Liquid	No	No
Compra Pintura	Proshield Premium	2.5 l	Liquid	No	No
ECOS PAINTS	EMR/EMF Shielding Paint	1 US Quart (0.95 l)	Liquid	No	No
emf-protect	emfturtal Abschirmfarbe PLV	2.5 l (1,220 g)	Powder	No	No
GEOVITAL	Abschirmfarbe T98	1 l	Liquid	Yes	No
Gigahertz Solutions	Abschirmfarbe CFA40	1 l	Liquid	Yes	Yes
Graphenstone	PROSHIELD Premium	4 l	Liquid	Yes	No
PEN-YANG	Biologische Farb- und Putzbehandlung (Additive)	1 kg	Powder	No	No
Rustins	G Shield Electro Smog Shielding Paint	1 l	Liquid	No	No
STO	eProtect Color	10 l	Liquid	Yes	No
Stop Straling	Stop Straling	5 l	Liquid	No	No
YSHIELD	Abschirmfarbe HSF54	1 l	Liquid	Yes	Yes
YSHIELD	Abschirmfarbe MAX54	1 l	Liquid	Yes	Yes
YSHIELD	Abschirmfarbe DRY54	1 l (550 g)	Powder	Yes	Yes
YSHIELD	Abschirmfarbe HSF64	1 l	Liquid	Yes	Yes

BBD = best before date

**Table 3: Container size, type of material, batch number, and BBD used in the tests**

## 9 VOC content

Volatile organic compounds or VOCs affect well-being and increased concentration levels can lead to health symptoms and be harmful to human health.

The German Federal Environment Agency in Berlin writes on its homepage [iii]:

*„The English abbreviation VOC (Volatile Organic Compounds) stands for the group of volatile organic compounds. VOCs include substances of organic origin found in the air in gaseous and vaporous form. They include, for example, hydrocarbons, alcohols, aldehydes, and organic acids. Many solvents, liquid fuels, and synthetic substances can occur in the form of VOCs, as can numerous organic compounds which are formed during biological processes. Many hundreds of individual compounds can be found in the air at any time.*

*What health impacts can VOCs have?*

*Normally the concentration levels of individual VOCs are very low and represent no risk to health. The Federal Environment Agency has drawn up a representative overview of those VOCs which occur in homes in Germany. Concentrations which might possibly cause adverse health effects can arise as a direct result of construction or comprehensive renovation work, through improper work processes or the massive use of inappropriate products. Smell nuisances, irritations, and symptoms which can't directly be attributed to a particular disease have been described as acute health problems in people. Such effects, as well as chronic effects, which scientists have derived from toxicological assessments, must be avoided. This applies especially for carcinogenic, genotoxic, and teratogenic effects. If such effects have already been attributed to particular substances, then, according to the Regulation on Hazardous Substances, these may no longer be used in end products. What can't be completely excluded, however, is the possibility that VOCs with similar potential effects may be found in traces in a product, if they were either present in unchecked preliminary products or in recycled materials. A working group at the Federal Environment Agency has come up with guideline values for some frequently occurring VOCs with special significance in terms of their potential impacts on health.“ Source: [iii]*

Manufacturer/supplier	Product name	VOC	
		Information	g/l
Adoral	Anti Radiation Paint EWIFI	No	--
AegisGuard	AegisGuard LP (Additive)	No	--
AURO	Safe Shield No. 332	Yes	< 1
Biologa DANELL	HF-Abschirmfarbe HF65	Yes	0.2
BlocPaint	EMF/WiFi/RF Blocking Paint	Yes	< 1
Compra Pintura	Proshield Premium	Yes	0.65
ECOS PAINTS	EMR/EMF Shielding Paint	Yes	"Zero" after 14 days
emf-protect	emfturtal Abschirmfarbe PLV (Powder)	Yes	0.20
GEOVITAL	Abschirmfarbe T98	Yes	0.20
Gigahertz Solutions	Abschirmfarbe CFA40	Yes	0.20
Graphenstone	PROSHIELD Premium	No	--
PEN-YANG	Biologische Farb- und Putzbehandlung (Additive)	Not applicable	--
Rustins	G Shield Electro Smog Shielding Paint	Yes	22.00
STO	eProtect Color	Yes	< 1
Stop Straling	Stop Straling	No	--
YSHIELD	Abschirmfarbe HSF54	Yes	0.18
YSHIELD	Abschirmfarbe MAX54	Yes	0.19
YSHIELD	Abschirmfarbe DRY54 (Powder)	Yes	0.12
YSHIELD	Abschirmfarbe HSF64	Yes	0.17

**Table 4: General information and specific amounts regarding VOCs**

In accordance with Directive 2004/42/EG of the European Parliament and Council (of 21<sup>st</sup> April 2004), a maximum of 30 g/l of VOC is allowed to be released.

Insofar it is important to check the manufacturer statement regarding the VOC content of the product (see Table 4).

VOC content in shielding paints ranges from 0 to 22 g/l and can be found on the containers or in technical data sheets and product descriptions; in some cases, no information is provided at all. We did not send the shielding paints and additives for a separate lab analysis to independently verify the manufacturer information on VOC content.

YSHIELD and Sto are the only manufacturers who have this information independently verified by external laboratories (such as TÜV laboratory) and also guarantee the values. There are no test reports or confirming statements available from other suppliers.

## 10 Preparation of test samples

First, we determined the yield of the shielding product according to the instructions on the container or in the data sheet. Manufacturers specify yield either as an exact amount or a range on how many square meters of area can be covered with one liter.

*AegisGuard LP* is a special liquid that is added to a standard wall paint and is claimed to achieve a shielding effect in this way.

*PEN-YANG* offers an energized quartz powder that is added to a standard plaster or wall paint and is claimed to achieve a shielding effect in this way.

Both products have been mixed into a standard white wall paint according to manufacturer specifications. The description “material quantity in g/m<sup>2</sup>” refers to the specification for the white wall paint including shielding additives.

Manufacturer / Supplier	Product name	Yield according to data sheet	Amount of paint in g/m <sup>2</sup>	
			At min m <sup>2</sup> /l	At 6 m <sup>2</sup> /l
Adoral	Anti Radiation Paint EWIFI	6.6 m <sup>2</sup> /l (5 m <sup>2</sup> /750 ml)	170	187
AegisGuard	AegisGuard LP (Additive)	24 g/l paint (118 ml/5 l paint)	271	271
AURO	Safe Shield Nr. 332	7-10 m <sup>2</sup> /l	167	195
Biologa DANELL	HF-Abschirmfarbe HF65	3.75 - 7.5 m <sup>2</sup> /l	328	205
BlocPaint	EMF/WiFi/RF Blocking Paint	2 coats with 10 m <sup>2</sup> /l each	127	212
Compra Pintura	Proshield Premium	2 coats with 4-6 m <sup>2</sup> /l each	334	223
ECOS PAINTS	EMR/EMF Shielding Paint	13.3 m <sup>2</sup> /l	94	208
emf-protect	emfturtal Abschirmfarbe PLV (Powder)	4 m <sup>2</sup> /l	272	181
GEOVITAL	Abschirmfarbe T98	6-8 m <sup>2</sup> /l	215	215
Gigahertz Solutions	Abschirmfarbe CFA40	5-6.6 m <sup>2</sup> /l	249	208
Graphenstone	PROSHIELD Premium	10-14 m <sup>2</sup> /l	116	194
PEN-YANG	Biologische Farb- und Putzbehandlung (Additive)	4 g/l (50 g/12.5 l)	272	272
Rustins	G Shield Electro Smog Shielding Paint	5-6 m <sup>2</sup> /l	258	215
STO	eProtect Color	7.7 m <sup>2</sup> /l	160	206
Stop Straling	Stop Straling	7 m <sup>2</sup> /l	189	221
YSHIELD	Abschirmfarbe HSF54	4-8 m <sup>2</sup> /l	310	207
YSHIELD	Abschirmfarbe MAX54	4-8 m <sup>2</sup> /l	309	206
YSHIELD	Abschirmfarbe DRY54 (Powder)	4-8 m <sup>2</sup> /l	264	177
YSHIELD	Abschirmfarbe HSF64	4-8 m <sup>2</sup> /l	328	219

Table 5: Yield and amount of paint used for the test samples

After opening the can, a suitable paint stirrer helps to reach a spreadable consistency quite quickly; however, the stirring takes longer to spread the powder-based products evenly throughout the water. According to the user guide, the product by *emf-protect* needs to be stirred for 10 minutes.

The undiluted paints were applied to a 3 mm thick unprimed hardboard measuring 50 cm by 50 cm (20 in by 20 in). The amount of paint used follows the specifications for the highest amount per square meter or the smallest area per liter. See second last column under “at minimum m<sup>2</sup>/l” in Table 5.

A scale was used to ensure that the specified amount of paint was within +/- 1 g. The paint was swiftly applied – always by the same person – in short strokes in one direction on a piece of hardboard and then distributed evenly in both directions. Immediately afterwards, the weight was checked again.

After a drying period of 24 hours at ambient air, a second coat was applied in the same way.

Additionally, the exact same amount of each paint was applied to another series of panels. For more details, see the last column in Table 5 under “at 6 m<sup>2</sup>/l.”

## 11 Testing of adhesive tensile strength

Tests for adhesive tensile strength determine how well a paint adheres to a solid substrate.

### Process

The paint is applied with a film applicator at a 200 µm wet film thickness onto a smooth and solid substrate (a tile has been used in this case).

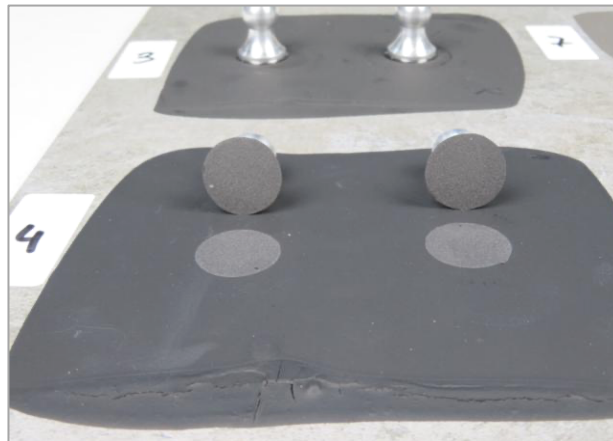
After a drying period of 24 hours at ambient air, a stamp with epoxy resin adhesive is glued onto the paint surface, according to manufacturer specifications.

After a curing time of 24 hours, the testing of the adhesive tensile strength can be conducted.

The value determined by the test device is recorded manually. The test has been conducted twice per paint.



**Figure 3: Shielding paint with two stamps each before testing the adhesive tensile strength**



**Figure 4: Stamps and pull-off image after testing the adhesive tensile strength**

The products by *AegisGuard LP* and *PEN-YANG Quartz Powder* are products that are added to a ready-to-use wall paint. In those cases, the adhesion value to the paint and not to the shielding product was determined.

In the German standard DIN EN 12004, adhesion values are defined for the categories C1 and C2:

- ▶ **Category C1** with at least 0.5 N/mm<sup>2</sup> meets the minimum requirements for all cement-based mortars.
- ▶ **Category C2** requires thin-bed mortars to have an adhesion value of at least 1 N/mm<sup>2</sup> and therefore describes a significantly higher standard of performance.

In real life, it happens again and again that tile cement is applied to substrates that were painted with a shielding paint. This is why Category 2 is used as a criterion for the adhesive strength.

Table 6 below shows the two individual measurement values, as well as the average (AVG).

An adhesive strength of at least 1 N/mm<sup>2</sup> needs to be achieved for Category C2. One product does not meet those requirements, two others are only barely above the threshold value.

The products from *AegisGuard* and *PEN-YANG* are additives for paints. Thus, the adhesive tensile strength depends on the wall paint and not the additive; therefore, these two products are not evaluated in the table.

Manufacturer/supplier	Product name	Adhesive tensile strength in N/mm <sup>2</sup>			Cat. C2 Met
		1. Test	2. Test	Average	
Adoral	Anti Radiation Paint EWIFI	9.03	9.09	9.06	Yes
AegisGuard	AegisGuard LP (Additive)	3.41	3.58	3.50	--
AURO	Safe Shield Nr. 332	0.82	0.72	0.77	No
Biologa DANELL	HF-Abschirmfarbe HF65	5.86	4.86	5.36	Yes
BlocPaint	EMF/WiFi/RF Blocking Paint	2.17	1.98	2.08	Yes
Compra Pintura	Proshield Premium	3.26	2.97	3.12	Yes
ECOS PAINTS	EMR/EMF Shielding Paint	7.00	6.90	6.95	Yes
emf-protect	emfturtal Abschirmfarbe PLV (Powder)	1.36	1.49	1.43	Yes
GEOVITAL	Abschirmfarbe T98	8.51	8.41	8.46	Yes
Gigahertz Solutions	Abschirmfarbe CFA40	6.03	6.28	6.16	Yes
Graphenstone	PROSHIELD Premium	1.23	1.09	1.16	Yes
PEN-YANG	Biologische Farb- und Putzbehandlung (Additive)	3.62	3.68	3.65	--
Rustins	G Shield Electro Smog Shielding Paint	3.33	3.75	3.54	Yes
STO	eProtect Color	5.17	5.54	5.36	Yes
Stop Straling	Stop Straling	3.49	3.54	3.52	Yes
YSHIELD	Abschirmfarbe HSF54	5.81	6.06	5.94	Yes
YSHIELD	Abschirmfarbe MAX54	4.10	4.04	4.07	Yes
YSHIELD	Abschirmfarbe DRY54 (Powder)	2.71	2.53	2.62	Yes
YSHIELD	Abschirmfarbe HSF64	3.74	3.64	3.69	Yes

Table 6: Measurement results of adhesive tensile strength

## 12 Grounding accessories

All wiring of electric circuits behind a surface painted with shielding paint needs to be equipped with a ground-fault circuit interrupter (GFCI) or residual-current device (RCD) (rated current  $\leq 30$  mA). There are two reasons why electrically conductive paints need to be bonded to an equipotential bonding bus bar for protective or functional potential bonding.

### 12.1 Personal and property protection

According to DIN VDE regulations (German Electrical and Electronic Information Technology Association VDE), this is about electrically conductive surfaces across which uncontrolled currents can flow if contact is made between a live part of the electrical system and the RF shielding. For example, this can happen when a nail is driven into the wall to hang a picture. Should the nail accidentally hit the

electrical wire – namely the current-carrying conductor (“hot”), not the neutral or grounding conductor – the entire section with the shielding paint will become live with an alternating voltage of 230 V (or 120 V).

In case the shielding paint of this wall is not bonded to a protective/functional equipotential bus bar, the person who comes in contact with this wall may sustain life-threatening injuries. However, if the shielding paint is correctly bonded and a GFCI or RCD is installed, the fault current would cause the circuit breaker to trip automatically.

## 12.2 Spread of ELF electric fields

ELF electric fields, which are emitted by the wiring of the AC electric circuits that run inside the wall covered with shielding paint, couple into the electrically conductive shielding paint and will then spread across the entire surface area. This, in turn, will lead to high exposure levels from ELF electric fields.

However, if the electrically conductive surface area is bonded to a protective/functional equipotential bus bar, the ELF electric fields will be automatically drained away and the ELF electric field exposure levels (otherwise associated with wiring in the walls) will not be measurable inside the shielded room anymore.

### CAUTION!

Bonding electrically conductive surface areas to the protective/functional equipotential bus bar must only be carried out by a licensed electrician.

Since 2007 German VDE regulations no longer allow to use water or heating pipes for grounding purposes. This regulation came about because there is no control over whether the metal pipes have been replaced completely or partially with plastic pipes over time. With such replacements in the piping system, the ground path would be uncontrollably interrupted.

A review was conducted on the necessary grounding measures recommended by the manufacturers and suppliers in their online instruction manuals and information sheets.

This is what we found:

- ▶ There are products for which the manufacturer provides no information, neither on the website nor the container, to the effect that the paint needs to be grounded. It is also not possible to buy appropriate grounding accessories from those suppliers.
- ▶ For other products, manufacturers call attention to the fact that the paint must be grounded by a licensed electrician, but they do not offer any grounding accessories. Licensed electricians often do not know how and where to bond a shielded surface area.
- ▶ For one product, we could not find any information on the container that grounding measures are necessary. On the website, however, there is one section regarding “Information on Grounding Products.”
- ▶ For another product, no information concerning necessary grounding could be found on the website nor any grounding products. A video on the product website shows a picture of the grounding accessories from the company *YSHIELD*. As the video continues, grounding is demonstrated with a self-made grounding kit. We urgently advise against the use of any self-made grounding accessories!
- ▶ Most products come with information regarding necessary grounding measures and the company also offers appropriate grounding products.
- ▶ In the instruction manuals of two products, however, grounding to a heating pipe is recommended. This practice, however, has been prohibited in Germany by the German VDE regulations since 2007!

- ▶ A few products offer extensive and detailed instructions on how to correctly install electrically conductive adhesive tapes, connections to a grounding plate, and connections to an equipotential bonding bus bar.
- ▶ The product from *PEN-YANG* consists of quartz powder that is not electrically conductive. Therefore, there is no need for grounding.

Manufacturer/supplier	Product name	Information on grounding	Grounding accessories	Comments
Adoral	Anti Radiation Paint EWIFI	No	No	
AegisGuard	AegisGuard LP (Additive)	No	No	
AURO	Safe Shield Nr. 332	Yes	No	
Biologa DANELL	HF-Abschirmfarbe HF65	Yes	Yes	Detailed and extensive
BlocPaint	EMF/WIFI/RF Blocking Paint	Yes	Yes	
Compra Pintura	Proshield Premium	No	No	References only in the product video with pictures of YSHIELD grounding accessories, later unprofessional grounding information
ECOS PAINTS	EMR/EMF Shielding Paint	Yes	Yes	
emf-protect	emfturtal Abschirmfarbe PLV (Powder)	Yes	Yes	
GEOVITAL	Abschirmfarbe T98	Yes	Yes	Wrong recommendation (grounding on heating pipe)
Gigahertz Solutions	Abschirmfarbe CFA40	Yes	Yes	Detailed and extensive
Graphenstone	PROSHIELD Premium	Yes	No	
PEN-YANG	Biologische Farb- und Putzbehandlung (Additive)	No applicable	Not applicable	
Rustins	G Shield Electro Smog Shielding Paint	Yes	No	
STO	eProtect Color	Yes	Yes	
Stop Straling	Stop Straling	No	Yes	Wrong recommendation (grounding on heating pipe)
YSHIELD	Abschirmfarbe HSF54	Yes	Yes	Detailed and extensive
YSHIELD	Abschirmfarbe MAX54	Yes	Yes	Detailed and extensive
YSHIELD	Abschirmfarbe DRY54 (Powder)	Yes	Yes	Detailed and extensive
YSHIELD	Abschirmfarbe HSF64	Yes	Yes	Detailed and extensive

Table 7: Grounding: Supplier information and accessories

### 13 Standard wall paints applied to shielding paints

All test panels with one coat of shielding paint have then been coated twice with a white wall paint. By doing so, the already dry shielding paint will again get in contact with moisture (water), which might lead to changes.

We observed changes in two paints only; the shielding effectiveness at 1 GHz decreased by a factor of approximately 2 (4 dB) or 8 (9 dB):

Manufacturer/supplier	Product	Decrease in RF attenuation in dB at 1 GHz
AURO	Safe Shield No. 332	4
ECOS PAINTS	EMR/EMF Shielding Paint	9

Table 8: Decrease in RF attenuation for two products after applying two coats of standard wall paint

## 14 Price comparison

Since manufacturers/suppliers provide different specifications for the yield of their products in square meters, a direct comparison cannot be made. Consequently, the author has specified the following procedure:

- ▶ For all shielding paints, the exact same amount of 6 m<sup>2</sup>/l was applied to the test panels. Based on this coverage of 6 m<sup>2</sup>/l, the price was calculated in Euro/m<sup>2</sup> according to Table 9.
- ▶ After a drying period of 24 hours. The RF transmission attenuation was measured and evaluated based on the attenuation value at 1 GHz.
- ▶ As usually larger surface areas are painted, bigger containers are bought. Prices as of November 2021 from online and brick and mortar stores form the basis of the comparison. Both special online promotions and shipping costs were not included. The prices indicated are end user prices including sales tax.

Manufacturer/supplier	Product name	Price	Price	Per dB	Attenuation
		Euro / l	Euro / m <sup>2</sup>	Euro / (dB @ 1 GHz and m <sup>2</sup> )	dB @1 GHz
Adoral	Anti Radiation Paint EWIFI	13.00	2.17	2.17	1
AegisGuard	AegisGuard LP (Additive)	* 1.45	0.24	--	0
AURO	Safe Shield Nr. 332	39.98	6.66	0.20	34
Biologa DANELL	HF-Abschirmfarbe HF65	49.98	8.33	0.21	40
BlocPaint	EMF/WiFi/RF Blocking Paint	45.20	7.53	0.20	37
Compra Pintura	Proshield Premium	11.44	1.91	0.14	14
ECOS PAINTS	EMR/EMF Shielding Paint	104.29	17.38	1.24	14
emf-protect	emfturtal Abschirmfarbe PLV (Powder)	37.33	6.22	0.44	14
GEOVITAL	Abschirmfarbe T98	113.60	18.93	0.46	41
Gigahertz Solutions	Abschirmfarbe CFA40	49.98	8.33	0.21	39
Graphenstone	PROSHIELD Premium	20.28	3.38	0.11	30
PEN-YANG	Biologische Farb- und Putzbehandlung (Additive)	* 0.003	0.001	--	0
Rustins	G Shield Electro Smog Shielding Paint	64.22	10.70	0.30	36
STO	eProtect Color	67.21	11.20	0.27	41
Stop Straling	Stop Straling	29.99	5.00	0.38	13
YSHIELD	Abschirmfarbe HSF54	49.98	8.33	0.20	41
YSHIELD	Abschirmfarbe MAX54	49.98	8.33	0.19	43
YSHIELD	Abschirmfarbe DRY54 (Powder)	24.98	4.16	0.13	32
YSHIELD	Abschirmfarbe HSF64	49.98	8.33	0.21	39

\* Prices were determined based on the amount added to 1 liter of wall paint.

Table 9: Cost overview

## 15 Measurement results of transmission attenuation of 19 samples

The frequency-dependent RF transmission attenuation of the shielding paints tested is shown for the range from 1 GHz to 40 GHz in the graphs of the below Figures 5–7:

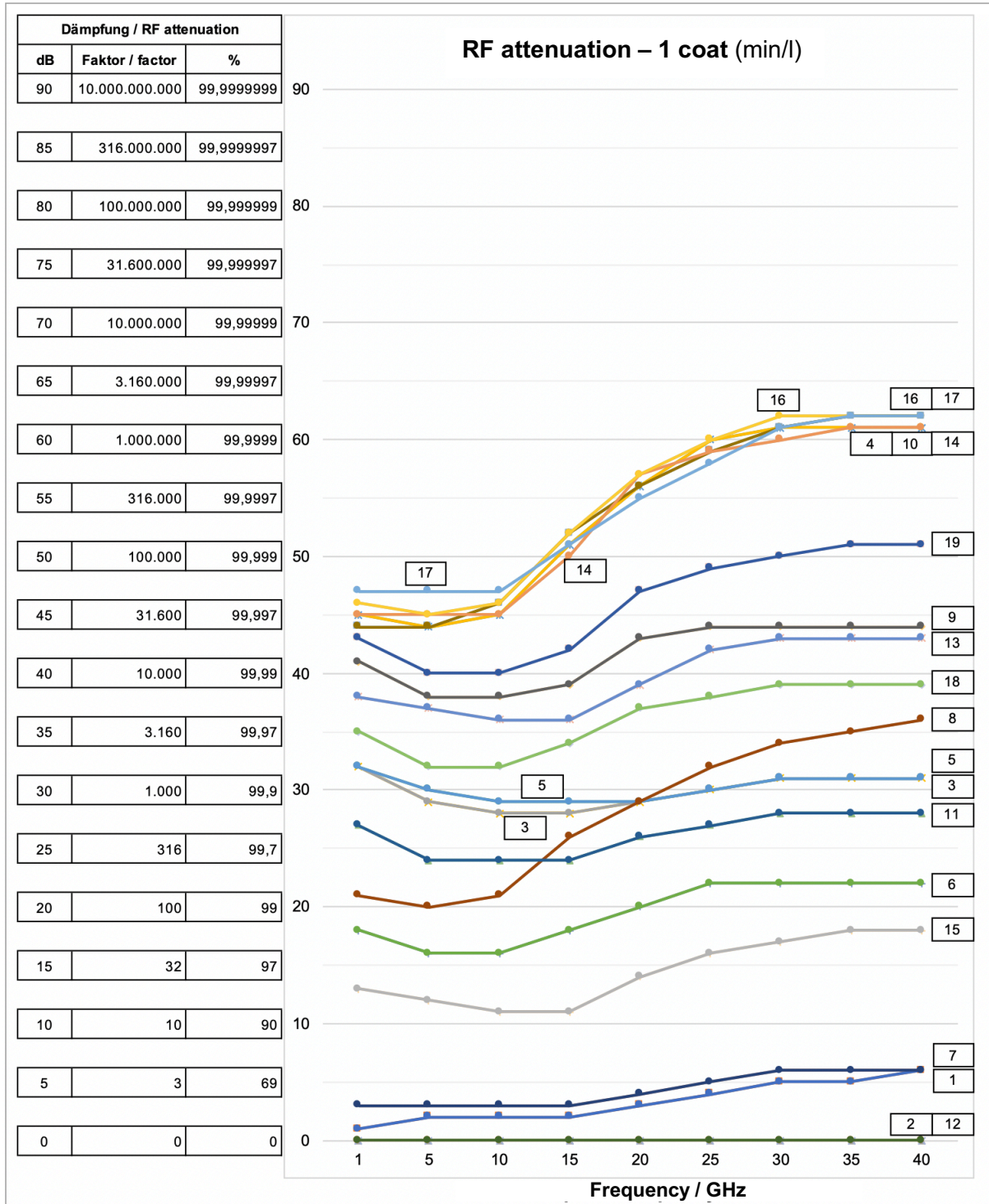
Figure 5: RF attenuation with **one** coat specified for a minimum area per liter (min/l)

Figure 6: RF attenuation with **two** coats specified for a minimum area per liter (min/l)

Figure 7: RF attenuation with one coat specified for **6 m<sup>2</sup>/l**

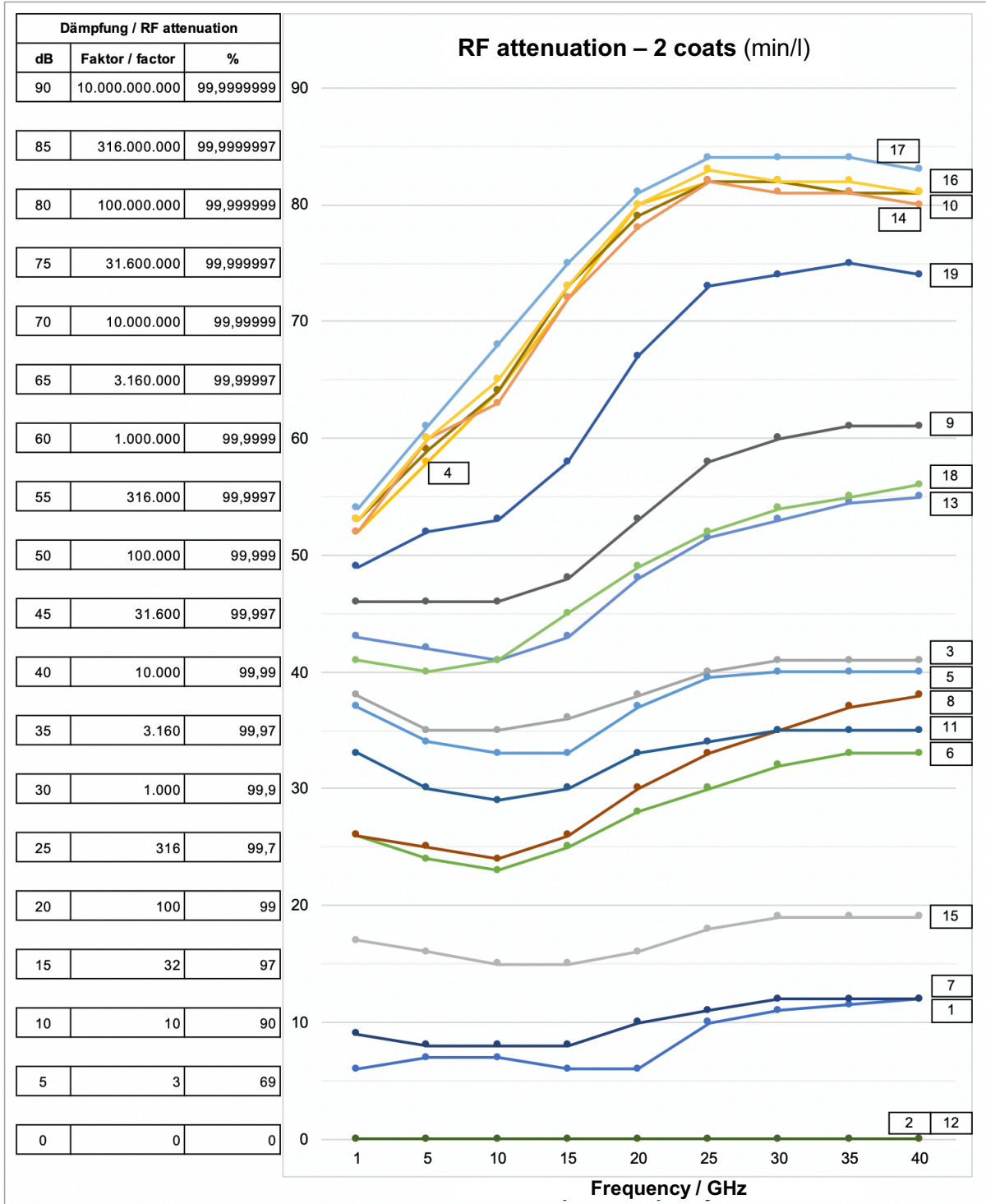
The factor and percentage values provided refer to the power density  $S$ . The factor for the field strength is equivalent to the square root of the factor for power density. The decibel (dB) value is the same for field strength and power density. Details of this relationship are described in [i], Chapter 12.





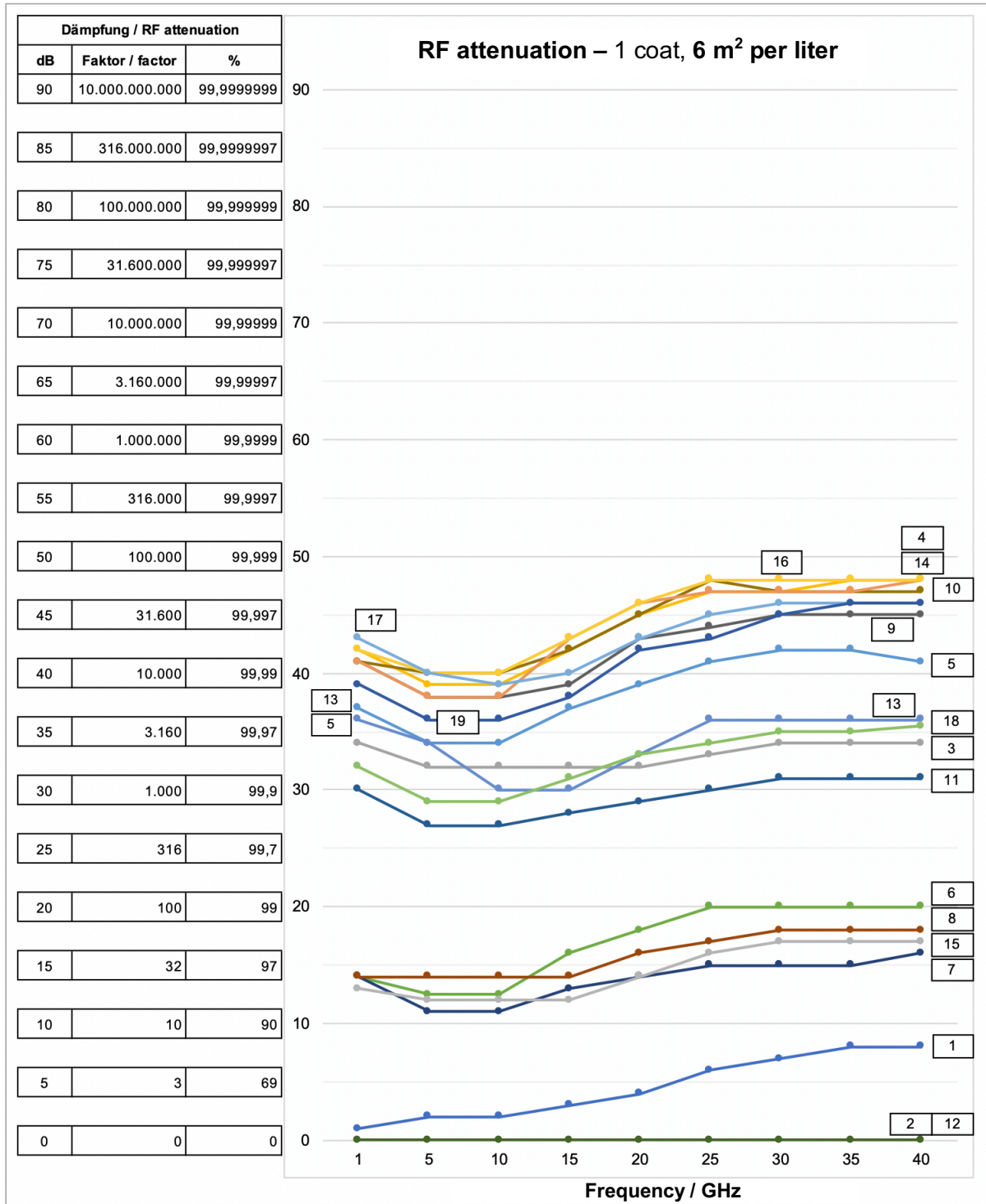
- |                                       |  |
|---------------------------------------|--|
| 1 Adoral Antiradiones ewifi           | 11 Graphenstone PROSHIELD Premium                |
| 2 Aegis Guard LP                      | 12 PEN-YANG Biologische Farb- und Putzbehandlung |
| 3 Auro Safe Shield Nr. 332            | 13 Rustins G-Shield                              |
| 4 Biologa HF65                        | 14 STO eProtect Color                            |
| 5 BlocPaint EMF Blocking Paint        | 15 STOP Straling                                 |
| 6 Compra Pintura                      | 16 YSHIELD HSF54                                 |
| 7 ECOS Paints EMR/EMF Shielding Paint | 17 YSHIELD MAX54                                 |
| 8 EMF Turtal                          | 18 YSHIELD DRY54                                 |
| 9 GEOVITAL T98                        | 19 YSHIELD HSF64                                 |
| 10 Gigahertz-Solutions CFA40          |  |

Figure 5: RF attenuation (factor and % for power density S) – one coat (min/l)



- |                                       |  |
|---------------------------------------|--|
| 1 Adoral Antiradiones ewifi           | 11 Graphenstone PROSHIELD Premium                |
| 2 Aegis Guard LP                      | 12 PEN-YANG Biologische Farb- und Putzbehandlung |
| 3 Auro Safe Shield Nr. 332            | 13 Rustins G-Shield                              |
| 4 Biologa HF65                        | 14 STO eProtect Color                            |
| 5 BlocPaint EMF Blocking Paint        | 15 STOP Straling                                 |
| 6 Compra Pintura                      | 16 YSHIELD HSF54                                 |
| 7 ECOS Paints EMR/EMF Shielding Paint | 17 YSHIELD MAX54                                 |
| 8 EMF Turtal                          | 18 YSHIELD DRY54                                 |
| 9 GEOVITAL T98                        | 19 YSHIELD HSF64                                 |
| 10 Gigahertz-Solutions CFA40          |  |

Figure 6: RF attenuation (factor and % for power density S) – two coats (min/l)



- |                                       |  |
|---------------------------------------|--|
| 1 Adoral Antiradiones ewifi           | 11 Graphenstone PROSHIELD Premium                |
| 2 Aegis Guard LP                      | 12 PEN-YANG Biologische Farb- und Putzbehandlung |
| 3 Auro Safe Shield Nr. 332            | 13 Rustins G-Shield                              |
| 4 Biologa HF65                        | 14 STO eProtect Color                            |
| 5 BlocPaint EMF Blocking Paint        | 15 STOP Straling                                 |
| 6 Compra Pintura                      | 16 YSHIELD HSF54                                 |
| 7 ECOS Paints EMR/EMF Shielding Paint | 17 YSHIELD MAX54                                 |
| 8 EMF Turtal                          | 18 YSHIELD DRY54                                 |
| 9 GEOVITAL T98                        | 19 YSHIELD HSF64                                 |
| 10 Gigahertz-Solutions CFA40          |  |

**Figure 7: RF attenuation (factor and % for power density S) – 6 m<sup>2</sup> per liter (one coat)**

## 16 References and links

- [i] Pauli, Peter; Moldan, Dietrich: Reducing Radio-frequency Radiation in the Built Environment: Building and Shielding Materials; 4<sup>th</sup> volume of the series “EMV topics of the VDB – Electromagnet Tolerance”; German Association of Building Biology Professionals VDB e. V. (ed.); April 2015, 3<sup>rd</sup> edition; AnBUS e. V. publishing house, Fürth; ISBN 978-3-9814025-9-9; <https://www.drmoldan.de/2020/12/23/buch-zu-hf-abschirmmaterialien/>
- [ii] Moldan, Dietrich: Abschirmung von 5G-Hochfrequenzwellen [Shielding of 5G Radio Frequency Waves]; in: Conference Proceedings of 10th EMC Conference „Energieversorgung und Mobilfunk [Power Supply and Wireless Communication Technologies]“ by German Association of Building Biology Professionals VDB e.V. on 17 May 2019 in Bergisch Gladbach; VDB e.V. (ed.); 2019, VDB e.V. publishing house, Jesteburg; ISBN 978-3-948407-01-8; <https://baubiologie.net/publikationen/emv/>
- [iii] German Federal Environment Agency: Volatile Organic Compounds; <https://www.umweltbundesamt.de/en/topics/health/environmental-impact-on-people/chemical-substances/volatile-organic-compounds-voc#what-are-the-sources-of-vocs>