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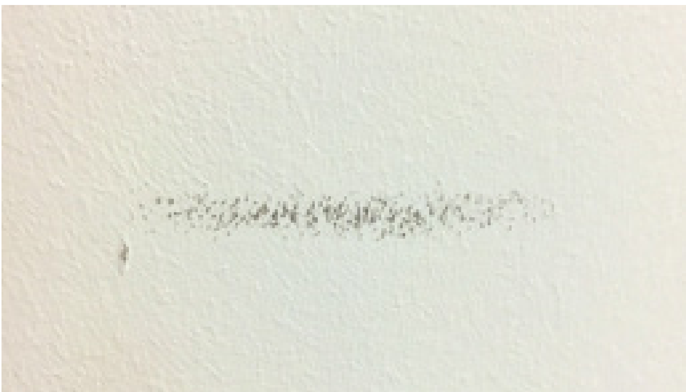
TESTING THE RESISTANCE OF WALL PAINTS TO "SCUFF"

A new test method enables the reproduction of soiling from scraping or wiping movements in a realistic manner.
By Jens Eichhorn, Byk-Chemie GmbH.

In science, using defined and reproducible test methods is essential, as only then is it possible to discuss and assess the established values. In the paints and coatings industry, it's often necessary to test application technology issues and challenges and make them measurable. One of these challenges is the resistance of wall paints to mechanical stresses. The newly developed test method means that soiling from scraping or wiping movements, e.g., from shoe soles, can be reproduced in a realistic manner.

To "scuff" means to "wear something out" or "chafe something". In engineering, "scuff resistance" is also known as "abrasion resistance" or "resistance to rough handling". If you search the term "anti-scuff" on the Internet, you'll find pages of so-called "anti-scuff sheets" which are used in the popular English sport of cricket. The bats are coated with foils which makes them more resistant to heavy-duty use during matches. However, scuffing is also a familiar problem in the world of paints and coatings. It is encountered daily in public buildings or at home (*Figure 1* and *Figure 2*). This refers to the typical marks or discolouration on walls, caused by the scraping of shoes, bags, jackets or other materials. For paints and coatings manufacturers, it is important to address this problem and develop systems, which are more resistant to scuffing. The information presented here is based on my bachelor thesis on the same subject, which I wrote in 2017 [1].

Figure 1: Example of scuffing on a standard wall paint (1).



RESULTS AT A GLANCE

→ The resistance of wall paints to scuffing is a familiar and still very current topic on the market.

→ The use of suitable test methods is required to address such application technology challenges.

→ It was possible to develop a reproducible and realistic replication of the effect using the skid resistance tester.

→ The soiling can be measured with the aid of spectrophotometers.

→ This challenge can be tackled by means of the correct formulation and the use of efficient surface-active additives.

DEVELOPMENT OF A SCIENTIFIC TEST METHOD

The development of a new method first requires some basic research. Manual tests were initially carried out using different materials from sole manufacturers and local shoemakers, and the phenomenon of scuffing was investigated. Microscopic images of such soiling have shown that different coatings and test materials used can cause differing effects. These include the mechanical abrasion of soles and the burning into the wall paint.

It was important to make these effects reproducible in a realistic manner and always under similar conditions. Familiar devices such as crockmeters or abrasion testers were initially used in order to do this. However, it was not actually possible to reproduce the scuffing effect, as these devices simulate a sustained, repeated load, and not a single swinging or wiping movement. It was thanks to comprehensive research on test equipment used in other sectors that the so-called skid resistance tester (referred to in the following as SRT) was discovered.

Figure 2: Example of scuffing on a standard wall paint (2).

DIFFERENT ORIGINS, NEW PURPOSE

This pendulum-shaped device was originally developed for a sliding resistance measurement of road marking paints. The SRT is therefore robust and built for mobile use, so that it can replicate the rubber of car tires impacting directly on the road surface. The rubber (*Figure 4*) is released from a defined deflection and the coating absorbs part of the kinetic energy of the fall. The pendulum then releases a pointer which displays a value on a scale which is then the measurement for the slip resistance of the tested paint. In our case, the rubber represents the sole of a standard shoe. The measurement of the slip resistance and the display on the scale are of secondary importance here. The falling motion should simulate the wiping movement on the wall and initially only the applied soiling on the coating is of interest.

NEED FOR REPRODUCIBILITY AND COMPARABILITY

In order to ensure that this method results in the recording of reproducible and comparable data and results, it is important that some parameters are always kept the same: Firstly, work must be conducted in an air-conditioned room under standard conditions, and secondly, the rubber used must be certified by the manufacturer. This ensures that the dimensions and composition are always the same. Different types of rubber with differing degrees of hardness are available; they usually have a shelf life of twelve months.

Figure 3 shows the experimental setup. Due to the locking or the height of the pendulum and the dimensions of the rubber, the pressure load on the coating is consistent every time a test is carried out. The support of the rubber on the pendulum shoe is spring loaded, which guarantees a consistent pressure across a defined route. It is therefore important to catch the pendulum after the swing and to prevent its return movement. By using the hook on the pendulum shoe, the device can be returned to the initial state. A second swing increases the homogeneity of the generated surface, resulting in greater measurement precision. Then, a dry cloth is used to remove the surface soiling or abrasion from the sample and the rubber. The actual scuffing effect is what is left behind. *Figure 7* shows a typical sample with a strong scuffing effect; by contrast, *Figure 6* shows a paint with very good scuffing resistance. To prevent any contamination on the rubber, a few pendulum swings are carried out over a fine

Figure 3: Skid resistance tester (SRT): overview.

sandpaper between two test systems. The length of the generated route is set by adjusting the device height and using a ruler (*Figure 3*).

COLOURIMETRICAL DETERMINATION

The use of these parameters and an unprofiled, smooth material produces an even and homogeneous surface with the soiling, which can then be measured colourimetrically with the aid of a spectrophotometer. For this process, a "spectro-guide sphere gloss" from Byk-Chemie was used. The measurements were carried out in the CIELab colour space which is generally used nowadays. The space, in which all colours imaginable can be found as colour locations, spans across a Cartesian coordinate system. The X and Z axes (in the case of a* and b*) form a level which is described by the complementary colour theory. According to this, the colours red and green are opposite one another on the abscissa, and on the application axis the colours yellow and blue. The ordinates represent the brightness values L* (0 = black, 100 = white). Using the coordinates assigned, it is possible

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \qquad \text{(Equation 1)}$$

to calculate colour differences between a sample and the associated standard using the equation

$$\Delta = \textit{Sample} - \textit{Standard} \qquad \text{(Equation 2)}$$

As the rubber used is black, the changes to the a* and b* axis are ignored and only the changes in brightness are taken into consideration. Using the generated ΔL values, the samples can therefore be compared with one another and assessed. If other materials are used, it must be decided whether or not it is more practical to use the ΔE* value.

LIMITS AND INFLUENCES

The tests have shown that the coating thickness does not have a great deal of influence. Samples with thicknesses between 100 and 200 micrometers (doctor blade gap) were applied and measured. Over time, or rather with an increasing number of tests and depending on the surface of the wall paint, the rubber was rubbed off and the contact surface changed slightly. However, no decisive influence on the reproducibility had been established so far. According to the manufacturer's information, the test material should usually be replaced after a year.
The surface structure of the system used, however, can have a great influence on the resulting effect. An agitated and structured surface also brings about a change to the contact surface and therefore pressure differences. This can lead to fluctuations in the results. Moreover, no homogeneous surface is therefore generated, which can lead to significant measurement errors. The friction during the load heats up the rubber over time. This can result in differences in the generated effects, which is why you should wait for a certain period of time between the tests, so that the material can cool down again.
Even if the effect usually takes place on substrates such as (woodchip) wallpaper and mineral substrates such as plasters, a non-absorbent, smooth substrate such as glass or plastic should be used for the test methods. Tests have shown that absorptive substrates, such as fiber cement (also with a barrier primer) can influence the surface to such an extent that no homogeneous effect can occur. By filling the sample holder

Figure 4: Image of a rubber attachment.

Figure 5: Ruler for adjusting the load surface.

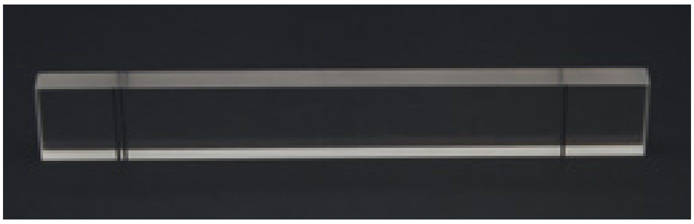


Figure 6: Sample plate with applied wall paint without scuffing (good).

Figure 7: Sample plate with applied wall paint with scuffing (bad).

(*Figure 3*, position 6) with uncoated glass or plastic sheets, a level surface with the floor tile can be achieved. This means that thinner, larger substrates such as contrast cards and sheets can also be used.
The test material (such as the rubber in this case) has a particularly large impact on the scuffing effect. The result can differ tremendously depending on the material (plastic, metal, textile, etc.) used. We decided to use plastic, as the original topic was the soiling from shoe soles.
If we consider the manufacture of shoe soles, we quickly establish that these materials are produced in very different ways. This starts with the chemistry used: there are two main representatives - rubber derivatives and polyurethanes. Additives, such as colour pastes for colouring, are added to these main components. The finished shoe soles are then produced using a spray or casting procedure. The components are sprayed or cast under pressure and temperature into a form and then hardened. It quickly becomes evident that the raw materials used have a significant influence on the properties of the sole material, and therefore also the subsequent scuffing effect. It has transpired that highly resistant polyurethane soles generate far fewer scuff marks than many styrene/butadiene-based variants. Then there's the stability of the colour pastes used. If the pigments are insufficiently stabilised, this will most likely also have a stronger effect. We tested various plastics, and a very critical variant with regard to the scuffing effect was chosen as standard. We therefore have the option to better evaluate the results and establish the differences.

CHALLENGE ACCEPTED

Having developed the correct test method, it is then possible to tackle the original topic. The project has shown: that the challenge of scuffing is not a trivial or easy one to solve. A skillful formulation and choice of raw materials is required in order to achieve good results. A high-quality binder matrix, the correct pigment/filler packing in conjunction with efficient surface-active additives is the key to creating resistant coatings.

REFERENCES

[1] Jens Eichhorn, Development of a Method for Testing the Soiling Tendencies on Wall Paints, University of Applied Sciences in Krefeld, 2017.

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"The same for all materials."

3 questions to Jens Eichhorn

Which test methods are usually used to determine scuffing? *Quick manual tests are often carried out in the industry. For example, the coating is rubbed directly against the shoe, which is being worn. There are numerous variations of the black heel marking test for floor coatings. There's even an ASTM method from the 1980s that is similar to our method.*

How realistic are the results of the new test method? *I developed the test method with the aim of making the simulation as realistic as possible. In other methods, the material being tested is shaken or moved while in contact with the sample over very long cycles. But the effect is normally produced by isolated wiping movements, and consequently reciprocating motion, too. If the effects are positive, I often use my own shoe, too, for good measure to verify the result.*

You've focused your work on the soles of shoes. Don't other objects like chair backs have more impact on painted walls, and would the results be similar? *It's true that chairs are a big problem in meeting rooms. But in public buildings or hallways and corridors, it's shoes that are the main concern. Shoe soles were also part of my thesis, so it made sense to continue focusing on them. But I've carried out accelerated tests with the tested samples on other materials, and I can confirm that the results are broadly the same for all materials.*