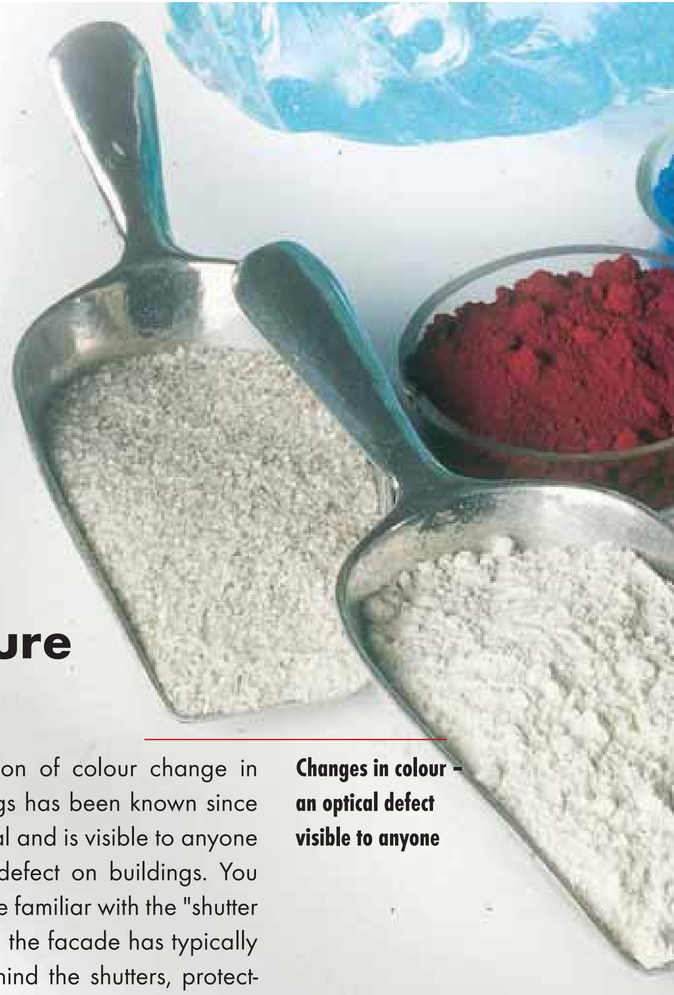
The „shutter effect" – and what's behind it

The colour stability of exterior coatings

Information for building contractors



Colour stability – a neglected quality feature

Colour as a design element

The colour which is selected for a building gives it its identity, the interplay of architecture and colour defining the character of the structure. The part played by colour in architecture is undisputed – for decades, even centuries, colour has been considered the fundamental design element.

The phenomenon of colour has long been the subject of study by psychologists investigating its impact on human emotions and well-being. Professional colour designers make very successful use of this knowledge in devising colour concepts.

Investing in colour design and paint is worthwhile because paint still remains the most economical and effective building design element.

Whether for a detached house or residential complex, for administrative or public buildings, for individual buildings or entire streets, well thought out colour concepts perceptibly enhance value and the user's well-being. They direct attention, impart identity, increase value and are not rarely the expression of an attitude towards life.

Changes in colour – an optical defect visible to anyone

The phenomenon of colour change in exterior coatings has been known since time immemorial and is visible to anyone as an optical defect on buildings. You too must also be familiar with the "shutter effect" in which the facade has typically faded, but, behind the shutters, protected from light and weathering, the original colour shade is still largely unchanged. This and many other phenomena associated with changes in colour shade greatly disrupt the overall impression made by a facade. They are not only unattractive but also ruin any colour design which had been chosen with effort and sensitivity.

It would thus seem strange that considerably more attention is not paid to the colour stability of coating products as a quality criterion.

Colour stability – wish or reality?

There is certainly no such thing as perfect colour stability, but there are still huge differences in the behaviour of coating products. Coatings whose colour shade remains unchanged to the human eye for decades are, for example, an entirely realistic proposition. It is, of course, quite true that there is scarcely a commercial coating product which is not promoted as being "UV resistant", "lightfast" or "colour stable".
But what are the differences? What has to be taken into account?

Factors influencing colour resistance

Light, weather, atmospheric pollutants, dirt

Colour stability and a constant optical impression over the long term are determined by a series of different factors.

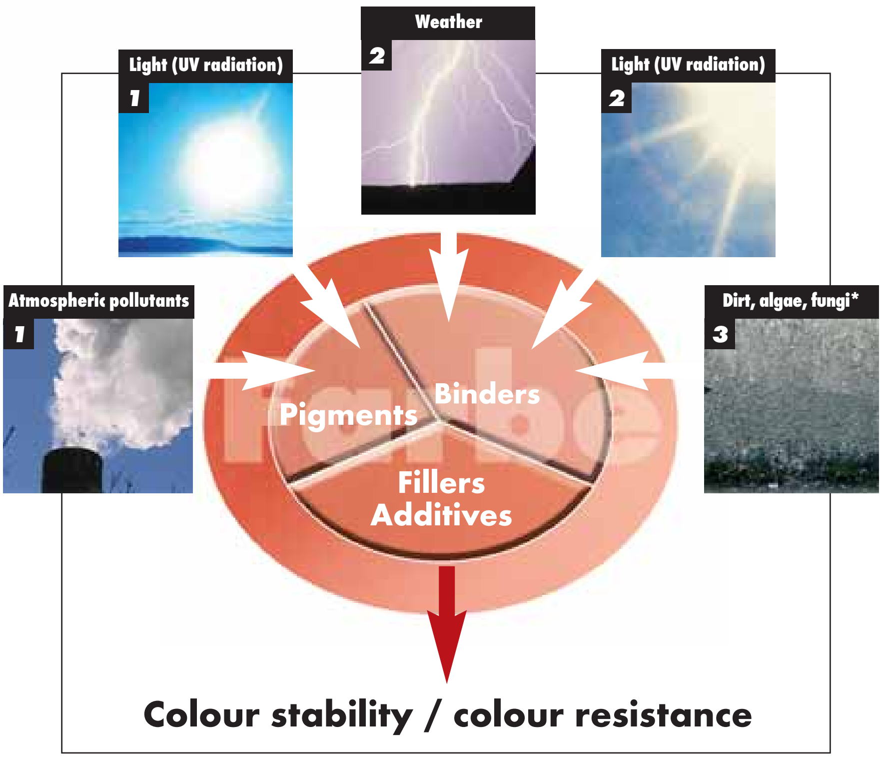
The most important are light, weather, atmospheric pollutants and dirt.

These act on pigments and binders, which are the coating ingredients which crucially determine colour stability.

1
Resistance of pigments to light (especially UV radiation) and to attack by pollutants from the atmosphere ("acid rain")

2
Resistance of binders to UV light and weathering

3
Soiling tendency/self-cleaning properties of coating surface as a function of the particular binder



**Information about plant growth on facades may be found in the brochure "Algae and fungi – verdant growth...".*

Resistance of pigments to light and atmospheric pollutants

There are two kinds of pigment – both in terms of material and resistance

Colouring pigments may be divided into organic and inorganic (mineral) pigments. The differences in the materials on which they are based result in differences in resistance between the two categories of pigments.

UV radiation can cause colour changes in pigments. This phenomenon is familiar from textiles: items of clothing which have been hung on outdoor display racks exposed to sunlight often have faded areas. Exterior wall coatings can suffer a similar fate if UV resistant pigments have not been added to the paint or have not been added in sufficient quantity.

Inorganic (mineral) pigments have the best light and UV resistance and retain their colour for decades.

In the same way that citric acid removes the organic dyes in fruit stains, aggressive atmospheric pollutants ("acid rain") may cause colour changes in pigments. ***Only selected inorganic pigments are acid resistant.***

Potsdam District Recruiting Office (Photograph taken 14.06.2004)

Left hand building: painted with KEIM silicate paint in 1992 (colour shade 9071)

Right hand building: painted the same colour shade with a competitor's organically pigmented paint in 1995 and already exhibiting a distinct colour change

What does this mean for the production and tinting of paints?

Pictures below: Seminary in Meersburg

On the left: north wing (south facade): original coating with KEIM Purkristalat dating from 1974 after 30 years' service life; bright, clean, unchanged in colour shade

By comparison, on the right: west wing (east facade): new coating with KEIM Soldalit from 2003

Organic pigments are frequently used for the production of exterior paints – they are available in large quantities and in an almost unlimited range of colour shades which are exactly reproducible during manufacture. As a result, these pigments simplify the handling and tinting of coating products.

Being based on natural raw materials and due to their manufacturing process, inorganic pigments are never absolutely uniform. Variations in the colouring properties of one and the same pigment from different batches are thus unavoidable. Moreover, being based on inorganic raw materials (completely in contrast with petrochemically derived organic pigments) means that only a limited number of colouring pigments are available. Nevertheless, thousands of natural looking colour shades, both light and intense, can be produced with them.

Silicate paints are generally formulated with such inorganic pigments, not least because many organic pigments cannot withstand the elevated alkalinity of the water glass binder (the binder for silicate paints). Accurately formulating defined colour shades with inorganic pigments is, however, incomparably more difficult than with organic pigments. Producing and, especially, reproducing inorganically pigmented colour shades demands considerably effort, experience and know-how.

IN A NUTSHELL:
Achieving colour stable coatings means using only high-quality inorganic pigments.

Resistance of binder to UV light and weathering

The UV resistance and "weather fastness" of the binder also play an important part in the colour stability of the finished coating. Like pigments, paint binders may also be divided into two major groups:

- ***organic binders,*** such as synthetic resin emulsion paints including silicone resin emulsions and
- ***inorganic, mineral binders,*** such as water glass (potassium silicate) or sol/silicate (silica sol/water glass mixture).

Light and weather – a harsh test for paint binders too

If the organic binder's resistance is inadequate, UV light and weathering, such as extreme fluctuations in temperature (hot/cold) or humidity (wet/dry), may give rise to microcracks in previously "smooth", continuous coating films and subsequently result in binder degradation.

Microcracks

Microcracks are ultrafine cracks in the coating layer which modify the refraction of the original "smooth" coating film and so give rise to modified optical properties. The colour shade of the coating appears greyer, cloudier and less clean. Moreover, water can penetrate into the substrate through the microcracks and, if the coating layer is not sufficiently open-pored, result in damage.

Organically bound coating after two years' weathering: microcracks in the previously "continuous" coating layer

Binder degradation

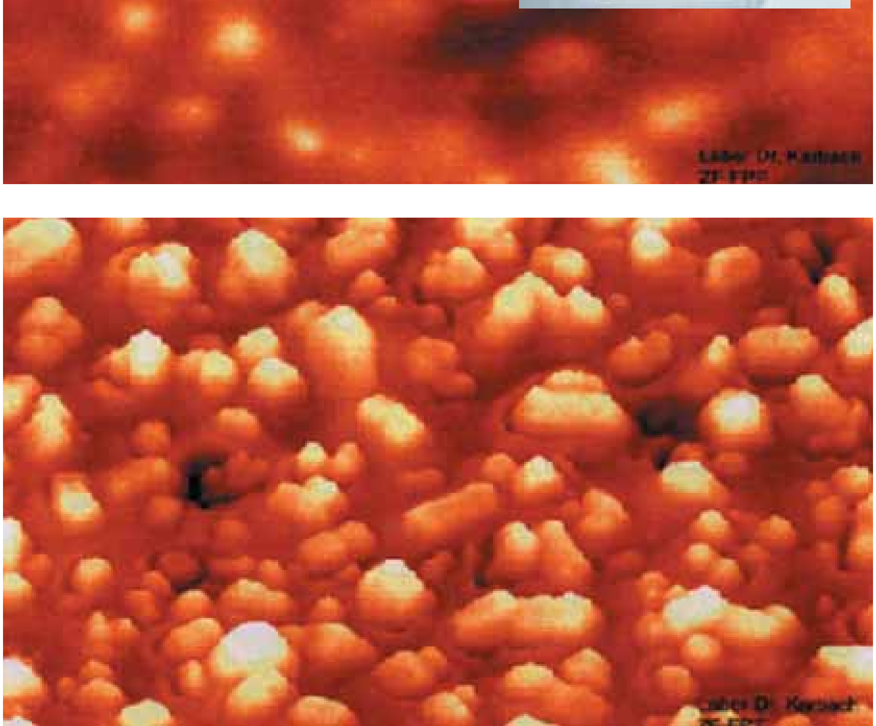
UV light and weathering can also destroy the binder, resulting in brittleness, instability and gradual degradation. Such binder degradation results not only in technical defects, but also in optical shortcomings: for example the slow destruction of the binder gradually "uncovers" the colouring pigments embedded in the binder, which are thus increasingly exposed to UV radiation from the sunlight. This additionally accelerates the colour change of the (organic) pigments. Moreover, because the pigments are inadequately "embedded" in the coating, weathering leaches pigment out, making the coating still paler. Such pigment leaching is frequently also the result of inadequate binding (= high pigment volume concentration), for example in "sil" paints.

Yellowing

UV light can also cause yellowing. We are familiar with yellowing from many areas of our daily life: yellow discoloration arises over the course of time due to the action of light, for example in porch roofs or plastic pots, because the binder is not sufficiently UV stable. A similar phenomenon may also occur in paints if they are based on such binders.

IN A NUTSHELL:
Mineral binders such as water glass or sol/silicate exhibit the highest UV resistance of all binders. Water glass and sol/silicate are also absolutely weather fast.

Yellowing: ordinary plastic bottle, upper half exposed to "sun test" for 250 hours



AFM micrograph: "binder degradation"

Top: new coating: pigments and fillers (white/light) are solidly embedded in the binder (red).

Bottom: after appropriate UV exposure: pigments and fillers (white/light) have been uncovered over large areas by binder degradation.

(Published with the kind permission of Kerr-McGee Pigments Ltd.)

Fig. 1
Exterior wall coating of silicate paint and silicone water repellent paint after two years' outdoor weathering

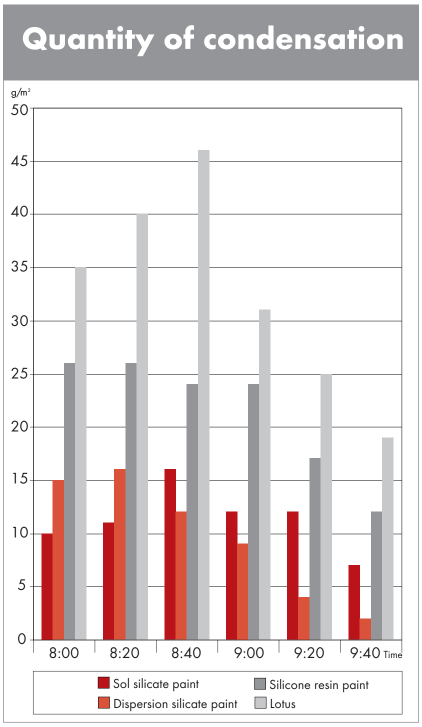


Fig. 2
Quantity of condensation on exterior wall coating (systematic outdoor measurements)

Soiling as a function of binder

Static charging, thermoplastic properties and condensation – complicated terms for simple natural laws

Static charging, thermoplastic properties and condensation – complicated terms for simple natural laws. Soiling also modifies the colour and optical appearance of exterior wall coatings. Although soiling (in comparison with pigment or binder changes) is relatively simple to remedy, vastly more attention has been paid in the recent past to the soiling behaviour of coatings.

The soiling tendency of exterior wall coatings is substantially determined by three factors:

- static charging
- the thermoplastic properties or "tackiness" of the binder
- and the surface's exposure to condensation

At low temperatures too, silicone resin paints are at a disadvantage relative to silicate paints because distinctly more condensation is deposited on silicone resin paints and this applies particularly to "lotus effect" or water repellent paints (see table above). As a result, silicone resin surfaces are wet for longer and dirt particles can accordingly stick on more readily.

Moreover, the risk of algal growth is also distinctly increased by the unfavourable condensation behaviour of silicone resin paints (unless toxic, leachable biocides are added).

Influence of binder on thermoplastic properties and static charging

Organic synthetic resin/silicone resin binders become electrostatically charged in the wind due to friction and so actually attract dirt particles onto themselves from the air. At higher temperatures, these binders additionally exhibit thermoplastic behaviour, i.e. they become tacky when hot. Dirt particles blown in the wind and attracted by the static charge thus find ideal adhesion conditions and "stick" to the surface. Silicate binders, in contrast, do not behave in this way.

Soiling – practical example
Private house in Lucerne, painted white at the same time.
Left: silicone resin paint
Right: silicate paint

Augsburg Town Hall painted with silicate paint, after 20 years' service life

Clean facades – wish and reality

What experience has taught us

In the recent past, extreme water-repellency (= "hydrophobicity") has been the focus of considerable and heated public debate in relation to "clean facades" and the "lotus effect".
The extent of water-repellency of paints is largely controlled by the addition of appropriate additives, such as silicone oils.
Paradoxically, however, silicone oils result in greater adhesion of dirt particles. The "water-beading" effect presented in laboratory tests and in advertising posters has not proved advantageous in practice – quite the contrary. Many building exteriors coated with these extremely "hydrophobic" paints suffer from very severe soiling. Water droplets carrying particles of dirt roll down the facade, come to a standstill on a particle of render and get stuck there
(see Figure 1).

Figure 1

Recent results confirm the advantages of silicate paint

The most recent studies likewise confirm that there is no connection between the "beading" effect and the "cleanness" of facades. Instead, systematic investigations have now confirmed what has already been evident for years and decades from coated structures – namely that silicate coatings exhibit the best behaviour in terms of cleanness and soiling resistance.

This is primarily due to the above-described properties of silicate paints – antistatic, non-thermoplastic properties, low levels of condensation, favourable wetting characteristics – all of which are largely determined by the silicate binder water glass. The phenomenon of "micro-chalking" additionally assists by providing controlled nanometre-scale "sanding", caused by weathering, of the coating layer which proceeds uniformly over a period of decades and results in a constant removal of any deposits of dirt which do occur.

IN A NUTSHELL:
Silicate paints, by their nature, have a lower tendency to soiling than emulsion or silicone resin paints. Silicate paints are antistatic, non-thermoplastic and their surface is drier for longer.


Colour resistance – what do paints actually do?

There is certainly no such thing as perfect colour stability, but there are still huge differences in the behaviour of coating products, something which practical experience teaches us time and again.
The difficulty resides in demonstrating or measuring these differences. Specialists in the field are unanimous: there is no reliable, laboratory test method which is capable of simulating real conditions of exposure and could so provide results of practical relevance. If realistic statements are to be made, the only solution is outdoor testing in a true to life situation.

First systematic investigations into colour change

Now for the first time a systematic investigation of this issue has been carried out by a neutral party: the coating materials and paints research and development company "Forschungs- und Entwicklungsgesellschaft Lacke und Farben mbH" has carried out comparative outdoor weathering tests over four years on five different exterior paints with different types of binder and assessed them in relation to colour change.

The parameter investigated was the colour difference of the individual coatings after completion of four years' weathering in comparison with an unweathered reference sample which had been stored in the laboratory protected from light and moisture. The assessment or measurement of colour difference also included an evaluation of pigment changes, binder changes, soiling and plant growth.

Colour changes around the shutters and under the eaves are clearly visible from the pictures.

Tested exterior paints

Five exterior paints with different types of binder were specified as the test products. These were a pure, two-component silicate paint, a silicate emulsion paint, a (silica) sol/silicate paint, a lotus effect silicone paint and a pure acrylate exterior paint. The particular products tested were deliberately selected to be of the highest quality in their particular category.

The colour shade selected was an intense blue (NCS S 2050-R80) because blue shades are particularly sensitive to weathering, and the human eye is particularly good at and sensitive in discriminating colour differences in the blue/grey range. Only the silicone paint had to be used in lighter colour shade because the desired NCS colour shade could not be supplied.

iLF Forschungs- und Entwicklungsgesellschaft Lacke und Farben mbH, Magdeburg (2001 – 2005)

Method

Parallel outdoor weathering tests were carried out to DIN EN ISO 2810 in two different climates, one the industrial climate of Magdeburg and the other the rural climate of southern Bavaria. In this way, climatic conditions could also be taken into account, so additionally ensuring the general validity and practical relevance of the results.

Test methods

Both visual and instrumental methods were used for testing. All test methods were based on generally recognised standards.

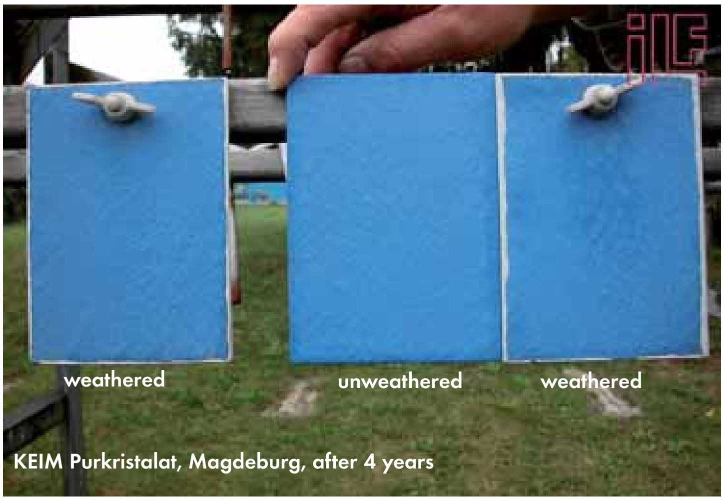
Results of outdoor weathering tests of five exterior paints

Results of practical study

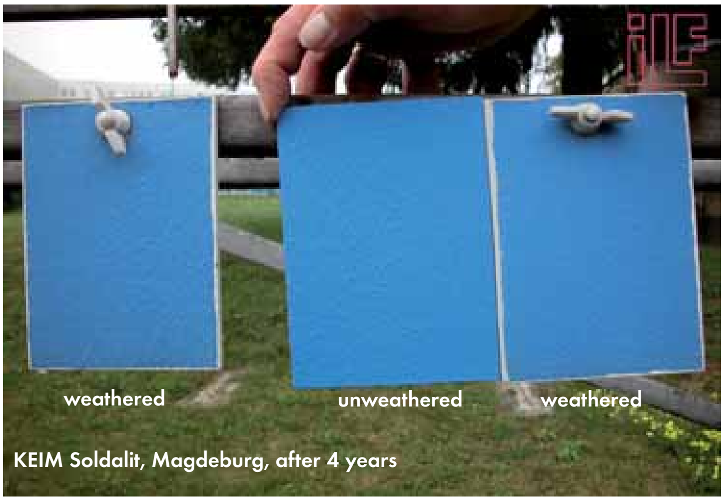
After four years of outdoor weathering in an industrial climate and in a rural climate, no adhesion problems in the form of cracks or blisters occurred in any of the exposed samples.
In terms of decorative properties, the investigated silicate products all exhibited distinctly less change than the silicone paint and the acrylic paint.
This is impressively clear from the instrumentally measured delta E value and blue value. ***The silicate product accordingly exhibit the best colour stability.***

The extent to which the superiority of the silicate products is manifested in terms of colour stability is clear from the photographs, which speak for themselves.

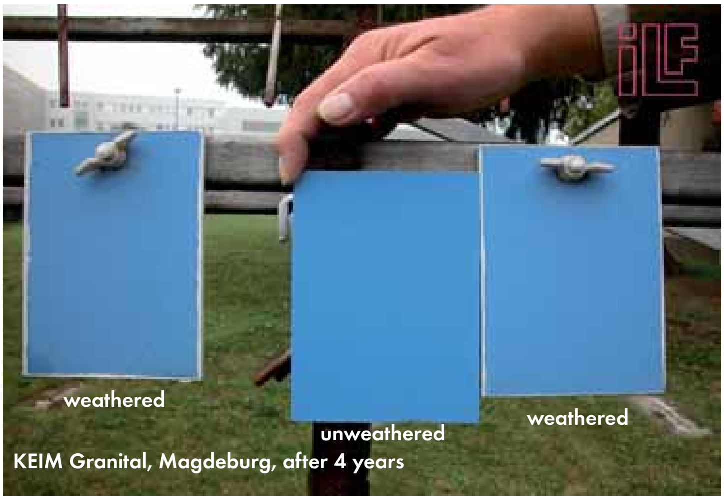
IN A NUTSHELL:
The superiority of high-quality silicate paints over polymer and silicone resin bound exterior paints, which has so far been seen and experienced on countless structures, has been impressively substantiated by comprehensive tests carried out by Forschungs- und Entwicklungsgesellschaft Lacke und Farben mbh iLF.



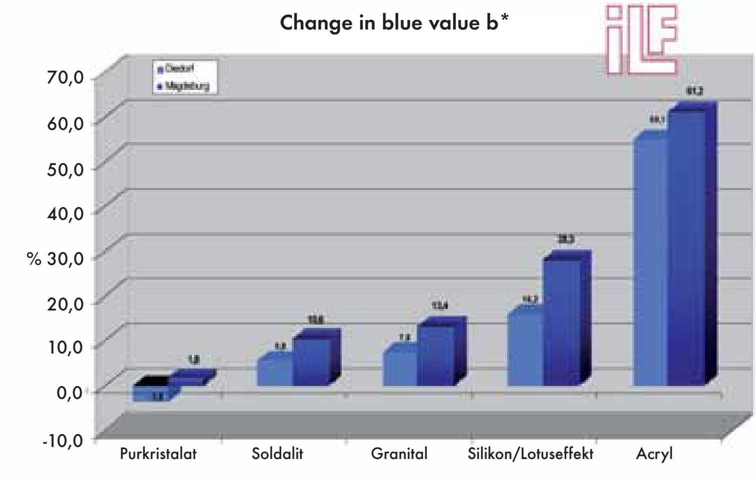
KEIM Purkristalat, Magdeburg, after 4 years

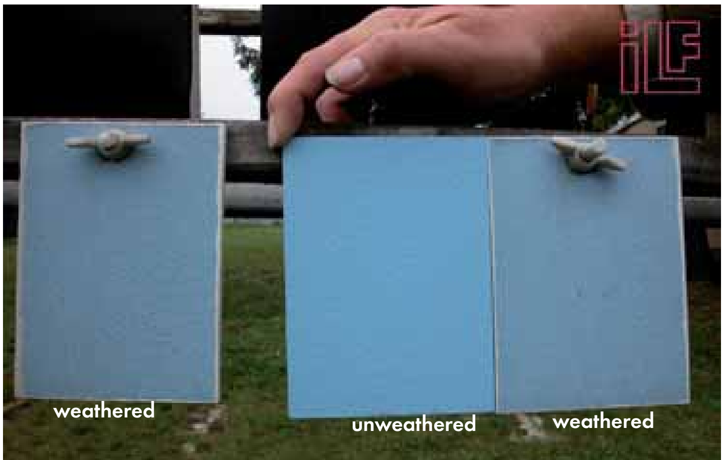


KEIM Soldalit, Magdeburg, after 4 years

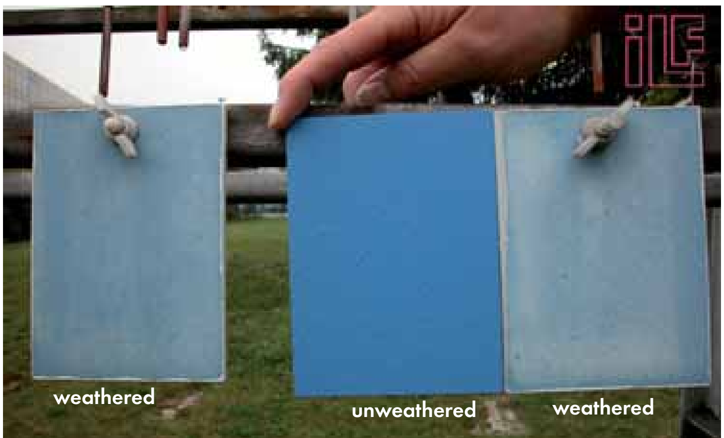


KEIM Granital, Magdeburg, after 4 years





Silicone exterior paint "with lotus effect", Magdeburg, after 4 years



Acrylic exterior paint, Magdeburg, after 4 years

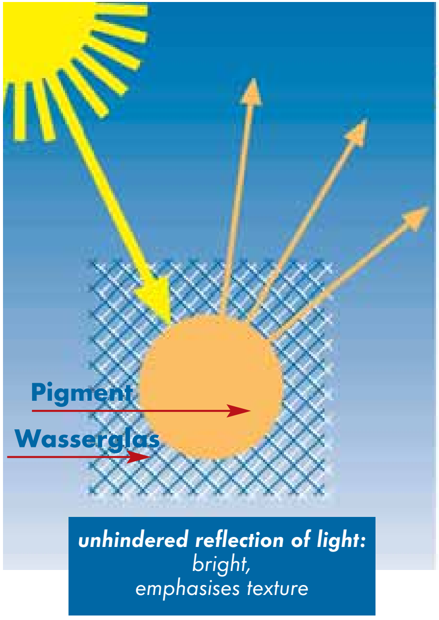
The problems of colorimetry

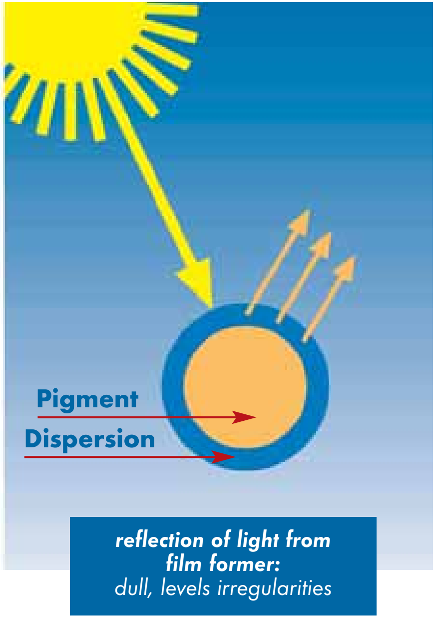
An appropriate colorimeter is used for instrumentally verifying colour shades and colour differences by determining the specific "colour location" of the colour shade within the three-dimensional "colour space".

Colour shades are defined by three parameters: firstly on a light-dark axis, secondly on a red-green axis and thirdly on a yellow-blue axis. If all three axes are visualised, a three-dimensional space is created.
This colour space comprises an infinite variety of subtly different colour shades. Each possible combination of the three values on the three stated axes represents a point within this colour space and thus a colour shade.
Conversely, the exact position within the colour space can be determined for each colour shade as the combination of the three coordinates. This combination unambiguously defines the colour shade. If the colour shade undergoes change, this can be unambiguously demonstrated instrumentally, the change being manifested as a change in one or more of these values on the axes. The sum of these changes is known as the "delta E value" which describes the "total colour difference" as the sum of the three colour differences on the axes.
The problem is that the delta E value is perceived differently by the eye depending on how delta E is made up and the particular colour shade in question:
delta E is the sum of three individual values. Accordingly, many different individual values can be added together to give the same result and thus the same delta E value. This is simple arithmetic: 1+2+3 = 6 is just as correct as 3+0+3 = 6, but while the result may be the same, a visual assessment may prove to be entirely different. The explanation for this is that human perception also differs in sensitivity depending on colour shade. In the case of blue or grey shades, our eye is highly sensitive and discriminates even very small delta E value as a colour difference. In the case of yellow-orange shades, on the other hand, our eye is fairly insensitive. In this case, small delta E values are not even perceived.

In brief: instrumental delta E values do not always correlate with what we humans see, especially when it is a question of the extent and intensity of a colour difference.

Silicate paint: *pigment embedded in transparent water glass*





Emulsion/silicone resin paint: pigment enclosed in cloudy emulsion binder

A brief aside on colour brightness

Glowing colours – matt and bright, a particular aesthetic issue

When discussing the colour stability of exterior wall coatings, the brightness of the colour shades should not pass entirely unmentioned because there are also visible differences between coating materials in terms of colour brightness. We usually take "brightness" to be an attribute like "silk-gloss" or "high-gloss" – both characteristics with which different grades of coating are distinguished and which describe the degree of surface gloss.
However, "brightness" does not necessarily mean gloss, but instead characterises another dimension of our perception: the luminance of paints and is not related to the degree of gloss.

The House of the Three Magi in Trier, painted with KEIM silicate paint, an impressive demonstration of the luminance of a matt silicate coating.

Light, pigment and binder

The luminance of paints is primarily caused by light impinging on the pigment and being reflected back. The less obstruction there is to light impinging on the pigment and being reflected by the pigment, the greater the luminance and "brightness" of the colour shade.

- Organic binders, as used in emulsion or silicone resin paints, form a film around the pigment and so modify refraction. The original luminance of the pigment is thus lost and the paint has dull and diffuse appearance.
- Mineral binders, as used in silicate paints, are transparent. They allow light to pass through unhindered and impinge on the pigment. Reflection is not distorted, the paint glows and looks bright.

IN A NUTSHELL:
Only mineral binders permit undistorted reflection of light from pigments, which so retain their original luminance and brightness.

Hermann Janiesch, proprietor of Janiesch-Farbenplanung, has successfully been using the insights of colour psychology to develop colour concepts for over 30 years.

www.janiesch-farbenplanung.de

"A colour concept can only have a lasting effect and success if the colour shades don't change ..."

"... colour is an elemental basic need ..."

"Colour perception is a highly emotional issue and no-one can escape the effects of colours. This is not always consciously realised as colour is an omnipresent part of our natural surroundings. Colour is not a matter of chance, it is a natural event. Colour is an elemental basic need and contributes considerably to human well-being.

Wrongly and meaninglessly combined colours trigger oppressive moods and produce an unattractive ambience, in which humans cannot feel at ease.
A skilfully devised colour concept is an ideal and economical option for creating positive moods and an attractive ambience – after all paint of the right colour costs no more than a wrong one.

The conscious selection and combination of colour shades can only have a lasting, successful effect if the colour shades of the materials used do not change. Changes in colour shade may have incalculable consequences and greatly impair the effects of a well thought out colour concept or, in extreme cases, even completely ruin it. Material selection is thus of particular significance when putting colour concepts into practice. Unfortunately, this issue is frequently neglected. We at any rate attach considerable importance to the use of high quality products for implementing our colour concepts, products we know will retain their original colour over the long term, such as products from KEIM."

Overview of key features:

Brilliant, luminous colour shades which are unchanging over the long term and clean exteriors are achieved if coating materials meet the following criteria:

- **UV and acid resistant pigments**
- **UV and weather resistant binders**
- **Antistatic surface**
- **Non-thermoplastic binders**
- **Minimal condensation, ideal drying**
- **Transparent binder**

Silicate paints ideally meet these criteria.

But theory is dull -
what ultimately counts are the practical results.
And silicate paints have been delivering results for decades all over the world.

Take the advice of your specialist company.

KEIMFARBEN
GmbH & Co. KG

Keimstraße 16
86420 Diedorf
Tel. 08 21 / 48 02-0
Fax 08 21 / 48 02-210

Frederik-Ipsen-Straße 6
15926 Luckau
Tel. 03 54 56 / 676-0
Fax 03 54 56 / 676-38

www.keimfarben.de
info@keimfarben.de

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Brief 1x1 of paints

Exterior paints are made up of three main constituents:

- **Binders**
- **Pigments**
- **Fillers**

Binders

The binder, as its name would suggest, binds the various constituents together and, above all, ensures that the paint adheres to the substrate. A distinction may be drawn between two large groups of binders: inorganic (mineral) binders (for example water glass, sol/silicate or lime) and organic binders (for example polymer emulsions including silicone resin emulsions). The difference resides primarily in the principle of adhesion:

Mineral binders also react chemically with the substrate, while organic binders adhere only by "adhesive bonding".

Pigments

(Colouring) pigments are very finely divided powders which have an extremely high colouring power. Addition of pigments imparts the colour to the coating material. In the case of pigments too, there are inorganic and organic types:

Inorganic pigments are obtained from purely inorganic raw materials (for example from minerals), while organic pigments are mainly manufactured from organic raw materials.

Fillers

Fillers are generally rock flours. The fillers provide the applied paint with the layer thickness which is required to protect the facade from weathering.

Most paints also contain additives. Additives are auxiliary substances with which various paint properties can be controlled (for example water-repellency, brushability, settling in the can etc.).