German Commission for Paint and Bodywork Repair

- Paint Guideline -
Basics For The Professional Repair Of Solid And Effect Paints On Road Vehicles

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Industrial initial coating in the course of series production at manufacturers, suppliers and industrial painters is continuously undergoing further development. These developments affect not only the paint materials and their components, such as the pigments they contain and the resulting effects, but also the necessary techniques for process-optimized, efficient and fully automated vehicle body and component coating, or "paint application" for short.

Vehicle coatings are regularly modified with regard to the types of paint and the paint build-up in order to create new color variants and effect impressions and, at the same time, to improve the so-called ecological footprint of the materials and processes used. Thanks to optimized equipment and innovative application methods, multi-layer topcoats in a wide variety of colors and effects can now be found in all vehicle classes and on an ever-widening range of models. In automotive factories, the painting processes have meanwhile been further developed up to fillerless automotive OEM coatings. The trend towards the introduction and implementation of paint technology advances in automotive production continues and is therefore inevitably having an impact on the essentially craft-based refinishing process.

This guideline has been revised by the German Federal Association for Color Design & Protection of Structure (Bundesverband Farbe Gestaltung Bautenschutz) with its Nationwide Expert Group Vehicle Painting (Bundesfachgruppe Fahrzeuglackierer – BFL) and the German Commission for Paint and Body Repair on the basis of the long-established BFL paint bulletin, thus replacing all previous editions and taking into account the current state of the art in refinishing. This paint guideline forms the basis for the assessment of vehicle coatings in the event of damage. It considers the range of all road vehicle categories and is used for this purpose.

Ultimately, the paint specialist on site decides on the execution of a professional refinish in the event of damage based on the refinish coating system to be used in the event of damage and the technical possibilities directly associated with it.

1. Preliminary Remarks And Definitons

The following section describes some generally applicable principles for the repair of solid and effect colors on road vehicles. Where necessary, additional information is provided in Chapter 2, subdivided according to paint type (characteristics of different color variants including color naming, paint layer build-up, gloss level and paint technology) and painting process.

1.1. Paint Scope

The damage and the possible painting process primarily determine the area or part-related scope of a refinish. In addition, the condition of the coating prior to the damage event must be taken into account. This includes any existing or already repaired previous damage to the surfaces and components to be painted as well as any recognizable color and effect differences.

A **full painting** includes either the painting of all visible exterior surfaces of a vehicle or the complete painting of all visible painted surfaces of the entire vehicle (exterior and interior surfaces).

Partial painting includes the painting of a partial surface of the vehicle. This can be a single part painting, if only one part (e.g. a door) is painted, or a parts painting, if several individual components are included in the repair painting. In both cases, moreover, the more extensive limitation to a component section, for example above or below a trim strip, can also be understood as such part painting. Partial areas of bodywork surfaces can only be painted if the shape and / or design of the bodywork / component(s) allows the paint area to be subdivided. Paint area subdivision may be possible on strongly pronounced edges and corrugations as well as on trim strips. Subdivision of the areas to be painted on less pronounced edges is only possible if a proper partial painting can be achieved by appropriate masking techniques. Obvious masking marks along corrugations, folds, edges and on the body surface must be avoided.

The following aspects must be considered in this regard:

- A possible subdivision of the paint surface is always influenced by the type, location and extent of the damage as well as the paint color, the mixing recipe and the layer build-up of the refinishing system used.
- The decision on a paint surface subdivision is the responsibility of the paint specialist carrying out the work, as the surface to be painted must be considered individually depending on the individual case and type of paint application. If necessary, the decision should be communicated to the customer, the expert and / or the insurance company or be agreed together.

- The technical functions of the coating must not be influenced by a surface subdivision and component separation and must continue to be guaranteed in the transition zones after the refinish has been carried out.
- The use of separating lines and masking edges along corrugations, folds and edges must be visually and haptically unremarkable and thus very slight or only noticeable at all to a trained eye.

The following Figure 1 illustrates the differences between the various coating scopes for repair paintings.

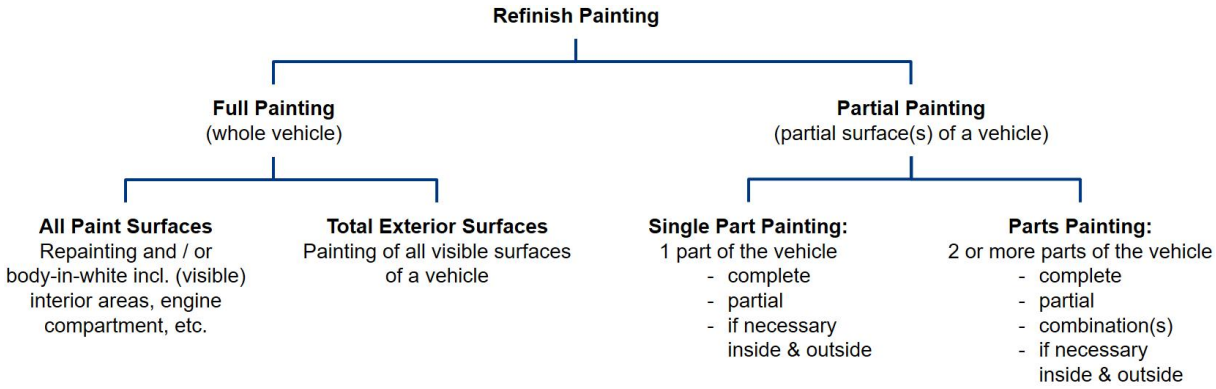

Figure 1: Differentiating features of refinish paintings based on the scope of painting.

1.2. Paint Build-Up And Topcoat System

Although this Paint Guideline is mainly concerned with the topcoating, the preparation of the substrate and the paint build-up with primer / corrosion protection, filler and primer are very important components that should not be underestimated. If the color of the substrate (filler or basecoat) is specified by the refinishing system used, this must be considered accordingly.

A "single-stage or multi-stage coating system" is the term used to describe the paint structure based on the required and successively applied individual paint layers. For this purpose, only those paint layers are considered which are applied from the filler layer onwards. This includes all basecoat and topcoat layers of different effects (from solid, metallic, pearl and Xirallic® to multi-effect and other effect paints), which are pre-painted as the base color or painted as the main color and / or effect-generating layer. In addition, all transparent, semi-transparent and pigmented clearcoat layers of different gloss levels (from high gloss to matt) and different surface structures (smooth, textured) are added. This so-called topcoating can thus consist of several paint layers with different functions.

Accordingly, 1-stage coating system is the term used for a topcoating carried out with just one topcoat material. A wide range of both solid and metallic colors can be painted as a 1-stage coating. For this purpose, for example, the RAL or NCS color palettes, but also individual company or fleet colors are available. The focus of 1-stage topcoating is on commercial vehicles of all kinds (trucks & vans, construction machinery ...). Two-component (2K) topcoats are predominantly used for 1-stage topcoatings in manual refinishing. These are highly pigmented paint binder resins, which are also used in transparent versions for 2K clearcoats. For this reason, the 1-stage topcoating is predominantly also referred to as a "2K (solid) topcoat".

2- and multi-stage coatings means that the final coating is applied with at least two different successive coating materials. Different constellations of basecoat and clearcoat can be used, allowing not only a wide variety of solid colors but also an unlimited number of color shades with various effects. If only one base coat color is recoated with transparent clearcoat, this is known as a 2-stage coating. If at least two different basecoat and / or clearcoat mixtures are applied in a defined sequence, this is called a 3- or multi-stage coating. In the case of passenger cars, 2- or multi-stage coatings, which are finally coated with a chemically cross-linked and durable clearcoat material, are now standard.

The visual impression of a painting is characterized by gloss, flow, color and effect. The automotive coatings can be subdivided according to paint type and effects according to the following Figure 2:

Figure 2: Subdivision of topcoats according to stages and effects.

Solid colors are single-color shades without effect pigments.

The metallic effect is based on aluminum pigments of various size grades from very coarse to very fine, which produce a more or less strong brightness-darkness flop.

Pearl effect paints produce an iridescent color flop due to the pearlescent or pearl effect pigments they contain.

Xirallic® pigments consist of very thin aluminum oxide flakes coated with highly refractive metal oxides (e.g. titanium oxide, iron oxide ...). This creates glitter effects intended to simulate the sparkle of a water surface or the starry sky. Xirallic® pigments per se have no light/dark flop, but are available with or without color flop depending on the metal oxides used.

Corresponding vehicle paints with a mix of the different effect pigments produce not only a brightness / darkness flop but also a color flop and / or glitter effect at the same time. In such cases, they are also known as multi-effect paints.

Special effect pigments consisting of a synthetic (silicon dioxide) or natural (mica) carrier material coated with highly refractive metal oxides cause color shifts that are strongly dependent on the viewing angle and trigger multiple reflections. This effect, which is based on physical principles of light interference, is based on pearls, fish scales, peacock feathers, beetle shells or crystals, amongst others.

In addition, the use of specially manufactured pigments, such as vacuum-metallized pigments (VMPs), enables other very special optical effects. For example, VMPs can be used to create a highly reflective metallic surface by painting. This is often called a chrome effect or liquid metal effect.

By adding color inks to the clearcoat or transparent base coat and applying several successive layers of paint, it is also possible to create a depth effect with chromatic and achromatic color shades.

1.3. Uniform Coating And Blending

A refinishing process is the uniform coating of the surface(s) to be repaired. This is applicable to all types of paint.

Another process is painting with a transition, called blending method. Blending with color and effect layers is used for two-coat and multi-stage paints, if it is not possible to achieve an appropriate color match in any other way. In the case of a color and effect match, the basecoat is applied beyond the actual and prepared damaged area and the entire part or the parts affected by it are completely repainted with clearcoat. To minimize the so-called "magnifying glass effect", the clearcoat thickness at the component edge should be kept as low as possible. It is therefore advisable to always observe the state of the art and the recommendations of the repair paint manufacturer used.

Basically, the blending method is further subdivided into

- Blending in the part (blending within a part / in an area)
- Blending / color matching of adjacent parts (blending in the adjacent part(s))

The decision on any form of blending is made by the paint specialist carrying out the work, taking into account visual and economic aspects based on the location of the damaged area, the extent of the damage, the surface geometry, the body structure and the possible zoning of the body, as well as the type of paint and paint build-up.

This is of particular importance in the case of components whose surfaces merge directly into adjacent components without clear boundaries or separating elements. Here it is necessary to find a solution that is both technically justifiable and economically viable, taking into account any vehicle manufacturer specifications. A solution can also lie in the flowing out application of the clearcoat with final polishing of the transition zone.

It is also necessary to consider the extent to which the existing vehicle paintwork has been visually affected over time by weathering or environmental influences in conjunction with the aging process. This surface condition must be considered when deciding on the way of painting, although it does not categorically exclude the possibility of blending.

The decision on blending within the part or of adjacent parts is always made by the paint specialist carrying out the work on the basis of the color samples he[1] has painted himself and in accordance with the current state of the art and, if necessary, with the support of suitable aids. This decision may have to be discussed and justified with the customer, the expert or the insurance company.

1.3.1. Blending In The Part (Blending Within A Part / In An Area)

"Blending in the part" means the smoothly painted transition with basecoat from the repaired damaged area to the existing undamaged painted area to achieve a color tone and / or effect match within the part.

[1] For the sole purpose of better readability, gender-specific spelling is not used. All personal designations in this document are therefore to be understood as gender neutral. The masculine form chosen throughout is not to be regarded as gender-specific within the meaning of the Equal Treatment Act and therefore always includes female or diverse persons equally.

Blending in the part is the preferred method for 2- and 3-stage coatings and for minor to medium damage, as long as the position of the damaged area in the part and the resulting processing surface enables this. In addition to economic aspects, the fact that any differences in color tone and / or effect are concealed within the component and not carried to the edge of the adjacent part is a clear argument to favor this process. The refinishing system used is also a decisive factor in this respect.

From a technical point of view, 4-stage coatings with colored precoat and colored clearcoat cannot be applied in the damaged part using manual coating processes. Caused by the limited surface area available, visually perceptible transition zones (e.g. dark edges) result from the overlapping of the repair paint with the existing original paint.

1.3.2. Blending / Color Matching Of Adjacent Parts (Blending In The Adjacent Part(s))

The term "blending" or "color matching of adjacent surfaces or body parts" is used when the visible surfaces or components adjacent to the damaged or renewed component must be painted as well, even though they were not originally damaged. In this case, the clearcoat surface of the adjacent components is finely sanded evenly. The basecoat is then applied to the appropriately prepared neighboring surfaces, fading out and in gradual transparency over the existing paint. All parts are then completely repainted with clearcoat. As a result of the application of the additional paint to adjacent components, a visual match is achieved in terms of color tone, color nuance, effect, structure and gloss level. The aim here is to achieve an even (color and effect) flow from the actual damage to the immediately adjacent components in a professional manner.

In the case of 3-stage coatings with precoat or colored transparent basecoat, these are also painted to run out and then completely repainted with transparent clearcoat.

In the case of coatings with tinted clearcoat, this is also applied with a fade-out application. In the same operation, an uncolored clearcoat is applied from the opposite side, so that both fade-out zones meet at the transition zone and form a surface with good flow.

Depending on the refinishing system used, however, subsequent topcoating with a transparent clearcoat is necessary to ensure the required durability. In addition, topcoating with a transparent clearcoat leads to significantly simplified polishing and thus increased process reliability. The polishing of imperfections in the colored clearcoat can, depending on the extent, lead to discoloration in the paint film, as the coloration is reduced at the sanded and polished areas. In any case, the specifications and recommendations of the respective refinishing system supplier must be observed.

It should also be considered that additional disassembly and assembly work may be required when painting adjacent parts, which may also necessitate the replacement of add-on parts that cannot be dismantled non-destructively.

When using the AZT Paint Calculation System, the parts painted to match the color are calculated with the "surface painting" painting grade.

1.4. Fade-Out Painting Of The Clearcoat With Final Polishing Of The Transition Zone

In the case of parts that do not have a direct boundary and whose surfaces merge into another one without separating elements (e.g. welded-in side panel at the transition from the C-pillar to the roof, without a separate roof frame or, in the entrance and sill area to the A- or B-pillars), the clearcoat can be applied with a fade-out method, provided that the paint specialist carrying out the work can justify this from a technical point of view on the basis of the special conditions on the vehicle and that it is technically possible for him to do so on the basis of the painting materials and aids available.

The decision whether to apply the clearcoat in a fade-out application process with final polishing of the transition zone is made by the paint specialist on site.

1.5. Basecoat Blending With Transparent Blender, Transparent 2K Mixed Coating Or Clearcoat

In the case of single stage topcoatings, the transition zone, i.e. the area where the topcoat fades out into the original coating, can be optimized by applying a transparent 2K binder (also known as mixed coating binder) or 2K clearcoat.

In the case of two- or multi-stage coatings, the transition zone can be optimized by applying a so-called blending additive (also known as "blender").

Product and application-specific information can be found in the technical data sheets of the refinishing system supplier used.

1.6. Angles And Levels

Whether the part to be painted is located with adjacent parts

- in the same level (e.g. fender - door) or
- at an angle (e.g. fender - hood)

must be considered when deciding whether to blend in and must be assessed by a specialist.

Furthermore, the body design of the vehicle to be repaired influences the possible perceptibility of minimal optical differences due to the individual surface geometry of the parts to be painted. This is briefly explained using the example of the "hood" and "fender", but can be applied to all other component combinations: Because the components "hood" and "fender" are usually arranged at an angle to each other, the visually perceptible differences in a vehicle refinish compared to adjacent parts in the same level are within larger tolerance ranges. For a professionally justifiable coating of the adjacent hood during the refinishing of a fender, or vice versa, the adjacent surfaces would have to lie horizontally and / or vertically in a common level over a correspondingly large area due to the design. Consequently, the best possible available repair color shade can exclude painting on edge. This may be the case for vehicle models with a corresponding vehicle design in conjunction with certain color shades.

In general, however, optical color tone and effect differences can always occur at different viewing angles.

1.7. Manual Refinishing Of Add-On Parts Of Different Materials (e.g. Plastic Add-On Parts)

In the case of add-on parts made of plastic (e.g. bumper covers, sill covers, trim panels, wing mirror caps, handles, trim strips, etc.), there may already be a visual difference in color tone and effect between the plastic add-on parts and the rest of the vehicle body when they are produced. This is due to a completely different pretreatment and coating process for plastic components. The technical boundary conditions required in plastic coating (stone chip protection, UV protection and adhesion to plastic, coating thickness, elasticity, flexibility, etc.) are achieved in appropriate quality by using a so-called corona treatment, plasma coating, flame treatment to improve adhesion and a specially adapted paint structure. This coating process is preferably carried out in especially designed coating facilities. This is mainly done as so-called "offline painting" by specialized industrial painting companies with "just in time" delivery or also in the production facilities of the vehicle manufacturers. The coating of such add-on parts is usually carried out separately and independently of the vehicle body and is not comparable with the painting of the body.

The challenge ultimately lies in the visual matching and alignment of the plastic add-on parts to the respective vehicle body. Complicating factors, such as different curvatures of the body component and the adjacent plastic add-on part and the resulting different light and color reflection in combination with a different alignment of any effect pigments present, prevent one hundred percent color tone and effect matching of the body and add-on part.

Plastic add-on parts are painted together with the vehicle body after appropriate pretreatment and surface activation only in a very small segment. However, it is not possible to achieve one hundred percent color and effect match between the vehicle body and the plastic add-on parts.

In the case of a refinish, it is therefore essential to consider the optical condition of the plastic add-on part and the adjacent body areas before the damage occurred. If there is already a difference in the color tone and effect match, this must be determined, documented and described. This condition then forms the basis for the restoration costs.

1.8. Color Variants Determination, Color Sample Preparation And Color Sample Verification

Color determination can be carried out in analog form, for example using color sample cards, or digitally by using a colorimeter. Color measuring devices (spectrophotometers) in combination with the color database of the refinishing system supplier support the paint specialist in searching for and determining the best possible formulation for the refinish..

The necessity of creating color samples is mainly based on the following criteria: Color variant, repair location or repair area, and extent and type of the upcoming refinish (partial painting with fading out within the damaged part, partial painting with blending into the adjacent part(s), partial painting with basecoat application up to the part edge; partial or full painting). Color sample preparation and color sample verification by the paint specialist carrying out the work are of particular importance in the case of repaired single part paintings where the basecoat is applied up to the next component edge. The same is valid for new part paintings of (plastic) add-on parts, compared to refinishing where the surfaces of the refinish and existing paint do not border on each other with continuous component edges in a visible surface (e.g. painting of one side of a vehicle). If a correction measurement of the color tone and thus a re-shading

is necessary, the creation of further color samples may be required. Depending on the paint type and structure, it may be necessary to paint several color samples. For example, the number and layer thickness of effect or tinting paint layers can be determined in this way for 3- and multi-stage colors. In the case of coatings with a reduced gloss level and coatings with a textured surface, color samples are very important for defining the appropriate matt or texture level and are therefore indispensable.

The preparation of color samples therefore depends on the particular job and is at the judgement of the paint specialist carrying out the work. The experience and expertise of the paint specialist in handling the refinish paint used are of decisive importance and, based on the knowledge gained, can influence the decision of the person carrying out the work with regard to the further repair procedure.

When using the AZT Paint Calculation System, the additional work can be captured by using the additional items "Mixing paint with mixing plant" and "Color sample and color determination".

It must be considered that one hundred percent color shade and effect match is not possible in all cases for refinishing paintjobs. On the one hand, this is caused by the differences between the series and refinishing paintings and, on the other hand, to the biologically determined differences in color, light/dark and contrast vision of the human eye.

1.9. Cost Calculation

The cost calculation of paint jobs can be carried out either with the documents of the relevant vehicle manufacturers or with multi-brand cost calculation systems such as the AZT Paint Calculation System.

The basis for calculating the paint material in most calculation systems (including AZT Paint Calculation System) is the respective paint type. This combines the properties "color shade including naming", "paint layer build-up", "gloss level" and the "paint technology". It should be noted that, depending on the calculation software provider and when the vehicle data and equipment are queried using the vehicle identification number (VIN)[2], the paint type may already be automatically predefined by the calculation software used. It should be noted that the data transferred from the VIN query, particularly regarding the paint type and paint naming, does not necessarily match the paint type of the refinishing system used. For a correct calculation result, the settings in the calculation software may therefore have to be adjusted manually.

A series production painting produced with a 2-stage topcoat system and shown accordingly by VIN may require a 3-stage painting in the refinish. A matt finish instead of a gloss finish, for example, can also result in a calculation that differs from the VIN query. For a correct calculation result, the settings in the respective calculation software must therefore be adjusted

[2] The vehicle identification number (VIN) is generated by the vehicle manufacturer on a vehicle-specific basis during production and the corresponding features are assigned once. Among other things, it provides information about the vehicle equipment as well as the color code and name of the painting, whereby the type of paint is identified based on the vehicle manufacturer's internal coding. Any changes made to the vehicle after the VIN has been assigned (e.g. retrofitting, repainting, etc.) are not subsequently recorded and can therefore not be displayed by the automatic query of the vehicle manufacturer via the damage calculation software provider

considering the specific circumstances and, if necessary, supplemented individually with reasons.

It should be possible to explain plausibly and comprehensibly whether and to what extent all the work items required for proper and professional execution of the paint job, as well as special features relating to the type of paint (e.g. matt finish or other special finishes), are included and taken into account in the individually used painting cost calculation.

Only the refinishing system available and used on site is valid for the calculation.

2. Paint Types & Painting Methods

The following information on the individual paint types is essentially based on the fundamentals described in Chapter 1. Where it appears necessary, short references are made, or additional information is included.

2.1. Paintings With 1-Stage Solid / Metallic Topcoat

Partial painting, i.e. painting of a completely affected body part or only a section of the part, is generally not a problem with 1-stage topcoat in solid color, depending on the color tone or color shade.

Depending on the color tone / color shade, it is also usually not necessary to paint the adjacent parts to match the color tone. Exceptions can be, for example, color tones that are only offered ready-mixed as so-called ready-mix paint and where the color shade differences are not acceptable.

In addition, the color of the filler must be considered.

The necessity of color matching on adjacent components on the same level must be checked individually in advance and documented accordingly.

The gloss level of the partial painting is matched to neighboring surfaces by polishing the directly adjacent areas. In the case of heavily weathered coatings, where the coating binders have already degraded considerably and/or the pigments have been washed out and altered by environmental influences, polishing cannot be used to achieve the desired effect properly or professionally.

It should also be noted that the hiding power of a 1-stage solid paint can vary considerably depending on the color tone and the components of the paint formulation used in each case, which means that if the hiding power is limited, a higher paint layer thickness must be applied to ensure a perfect painting result. In this case, the technical information of the refinishing system supplier used must be observed.

1-stage metallic paints are preferably found on commercial vehicles and construction machinery or occasionally on vintage vehicles (nitrocellulose paint / nitro combination paint). The repair of 1-stage metallic paints depends on the binder type and paint technology of the existing paint and the respective paint-technological possibilities. Therefore, the possible repair

method must be agreed with the customer for the individual case based on the refinishing system to be used.

2.2. Paintings With 2-Stage Colors

Partial painting with 2-stage paints is possible in principle. If possible, the basecoat should be painted in the part, as the color tone of the adjacent part remains almost unchanged. If technically necessary, the color shade can be matched on adjacent and neighboring parts in the same level.

Relevant 2-stage paintings are explained in more detail below.

2.2.1. 2-Stage Coatings With Solid Colors

Topcoat build-up:

(1) Solid basecoat
(2) 2K clearcoat[3]

Partial painting with 2-stage solid colors is possible in principle. Light solid colors such as white, yellow or red and colors in the pastel range are more difficult to reproduce and, compared with darker solid colors, are visually much less tolerant of slight color deviations.

Due to legal regulations, today's common lead- and chromate-free paint formulations contain some solid pigments with a comparatively low hiding power and must therefore be applied in a higher film thickness. Here, the color and brightness of the substrate (e.g. filler or undercoat) plays a significant role and has a decisive influence on the final color shade reproduction.

2.2.2. Paintings With 2-Stage Metallic Colors

Topcoat build-up:

(1) Metallic basecoat
(2) 2K clearcoat

Partial painting with 2-stage metal effect paints is possible in principle. It is more difficult to match the color and effect of the coating by changing the coating technique or by nuancing with metal effect color tones compared to solid color tones.

In particular, silver-colored metallic effect paints or color tones with a very fine effect in general (e.g. champagne, aluminum, ...) tend to form clouds and lines and therefore require a larger supplementary painting area for an invisible run-out zone of the basecoat compared to 2-layer solid paints.

In any case, the specifications and recommendations of the respective refinishing system supplier must be taken into account in order to achieve the best possible painting result, e.g.

[3] The term "2K clearcoat" is representative of the currently most commonly used clearcoat technology and includes any technology such as products curing under the influence of certain UV rays

with a filler or undercoat matched with the color of the basecoat, suitable setting of viscosity and evaporation rate, etc.

2.2.3. Paintings With 2-Stage Pearl Effect Colors

Topcoat build-up:

(1) Pearl effect basecoat
(2) 2K clearcoat

2-stage pearl effect colors are formulated with semi-transparent effect pigments and color-coordinated with the substrate. The substrate is largely responsible for the final appearance of the pearl effect painting, which is why the respective refinishing system supplier's specifications and recommendations for the appropriate color tone of the filler or undercoat must be considered.

Partial painting with 2-stage pearl effect colors is possible in principle. Matching the color shade and effect of the painting by changing the painting technique or by nuancing is more difficult and more complex with pearl color paints compared to 2-stage solid color paints. The hiding power can vary depending on the color tone, which sometimes requires an adjustment of the color tones of any filler surfaces. In any case, the specifications and recommendations of the respective refinishing system supplier must be considered.

2.2.4. Paintings With 2-Layer Xirallic® Effect Colors

Topcoat build-up:

(1) Xirallic® effect basecoat
(2) 2K clearcoat

Partial painting with 2-stage Xirallic® effect colors is possible in principle. Matching the color and effect of the painting by changing the painting technique or by nuancing is more difficult and more complex with Xirallic® effect colors compared to solid colors.

In any case, the specifications and recommendations of the respective refinishing system supplier must be taken into account in order to achieve the best possible painting result, e.g. with a filler or undercoat color-matched to the basecoat, suitable adjustment of viscosity and evaporation rate, etc.

2.2.5. Paintings With 2-Stage Multi-Effect Colors

Topcoat build-up:

(1) Multi-effect basecoat
(2) 2K clearcoat

A multi-effect paint consists of a mix of different effect pigments (solid / metallic / pearl color / Xirallic®), which means that a wide variety of color shades and effects can be combined depending on the color tone and nuance. A color and effect matching of the painting by changing the painting technique or by nuancing is therefore more difficult and more complex with multi-effect colors compared to all other 2-layer paints.

2.3. Paintings With 3-Stage Colors

Topcoat build-up:

(1) Basecoat basic step (solid, metallic, pearl color, Xirallic®, multi-effect, others)
(2) Basecoat second step (solid, metallic, pearl color, Xirallic®, multi-effect, others)
(3) 2K clearcoat

A 3-stage colorsystem consists of a basecoat basic step, a second basecoat step and a final uncolored 2K clearcoat. The first two coating layers are matched to each other in terms of color or, under certain circumstances, effect, and together produce the final color shade. The base color is applied opaquely, while the intermediate color is usually transparent, which means that different paint film thicknesses have a decisive influence on the final color. The second paint layer can be a solid color or effect basecoat, a transparent colored basecoat or an uncolored or colored 2K clearcoat.

Partial painting with 3-stage colors is possible in principle, but requires more effort and a very careful working method. The preparation of several color sample sheets is sometimes necessary.

Blending in the part is the method to aim for, but it requires more surface for blending compared to 2-stage painting with only one basecoat color.

If it is technically necessary, the blending of the adjacent and adjoining parts in the same level is a possible alternative.

Relevant 3-stage paintings are explained in more detail below.

2.3.1. Paintings With 3-Stage Pearl-Effect Colors

Topcoat build-up:

(1) Base color / colored precoat according to specifications
(2) Pearl-effect basecoat
(3) 2K clearcoat

In this setup, the pearlescent effect basecoat is used in a transparent mixture as an effect-generating layer over a basecoat of the same color (uniformly covering undercoat). The color shade and optical effect are also determined by the number of spray coats of the basecoat and are therefore dependent on the layer thickness. The number of required basecoat spraying passes must be determined using specially prepared color samples.

If it is not possible to fade out within the part (e.g. due to the location, type and size of the damage and the resulting processing area), the parts located in the same level and directly adjacent to the part must be blended in. Both the precoat and the pearlescent effect basecoat must be applied in a fading out manner.

2.3.2. 3-Stage Colors With Two Clearcoat Layers – Colored 1. Clearcoat Step

Topcoat build-up:

(1) Effect basecoat
(2) Colored 2K clearcoat
(3) 2K clearcoat

This is an effect coating with two clearcoat layers, in which the first clearcoat layer is colored. The optical effect achieved in this way appears deeper and enables a special brilliance of the color tone. The tinting effect depends on the thickness of the layers, which means that it is not always possible to ensure that the visual appearance matches that of the undamaged painted surface.

If it is not possible to fade out within the part (e.g. due to the location, type and size of the damage and the resulting processing area), the parts located in the same level and directly adjacent to the part must be blended in.

2.3.3. 3-Stage Colors With Two Basecoat Layers – Colored 2. Basecoat Layer (Transparent)

Topcoat build-up:

(1) Effect basecoat
(2) Transparent basecoat (colored)
(3) 2K clearcoat

This is an effect coating with two basecoat layers, in which the second transparent basecoat layer is colored. The optical effect achieved in this way appears deeper and enables a special brilliance of the color shade. The tinting effect is dependent on the layer thickness, which means that it is not always possible to ensure that an optical match to the undamaged paint surface is possible.

If it is not possible to fade out within the part (e.g. due to the location, type and size of the damage and the resulting processing area), the parts located in the same level and directly adjacent to the part must be blended in.

2.3.4. 3-Stage Colors With Two Clearcoat Layers and Intermediate Sanding Of The 1. Clearcoat Layer

Topcoat build-up:

(1) Solid / effect basecoat
(2) 2K clearcoat; Drying, followed by structure removal through intermediate sanding
(3) 2K clearcoat; if necessary incl. fine sanding and polishing

This process is intended to achieve an above-average surface quality. The vehicle manufacturer's repair guidelines and / or the technical service information and documentation of the respective refinishing system supplier will tell you whether the painted surface can be transformed as far as possible into a textured high-gloss surface by fine sanding and subsequent polishing.

Paint finishes of this type are also known colloquially as piano finishes or piano and mirror finishes.

2.3.5. Fluorescent 3-Stage Paintings

Topcoat build-up:

(1) Base color / intentionally selected precoat, usually pure white / bright white
(2) Fluorescent effect basecoat
(3) 2K clearcoat

The fluorescent effect, also known as "day glow", is only of limited duration. The UV additives contained in the clearcoat to protect against pigment destruction cannot resist the UV rays of daylight (e.g. from intense sunlight) for unlimited periods. The pigments used for the fluorescent effect thus lose their luminosity over time (process of aging / pigment destruction). As a result, the color tone changes. When a partial surface is repainted, optical differences may therefore occur between an existing and a new paint finish.

2.4. Paintings With 4-Stage Colors

In the case of 4-stage color paintings for which the refinishing system supplier used requires a correspondingly color-matched precoat for the respective color and which are painted with a colored first clearcoat or transparent basecoat layer and finally with an uncolored 2K clearcoat, partial painting of a larger area which is located closely in the same level as neighboring parts is not recommended..

It is not possible to blend in within the damaged part. Blending in of the adjacent surfaces requires a particularly wide transition zone for an fading out color match, since three color- and effect-generating layers have to be painted in a fading out process and thus a larger painting surface is required.

Under certain circumstances, a visually satisfactory recovery of the part to be painted is only possible by painting a visible surface, e.g. one side of the car. If this should be the case, it must be considered that a suitable procedure is selected for adjacent interior areas to avoid or minimize as far as possible a visible edge after the repair painting has been completed.

Relevant 4-stage paintings are explained in more detail below.

2.4.1. 4-Stage Colors With Two Clearcoat Layers – Colored 1. Clearcoat Layer

Topcoat build-up:

(1) Base color / precoat
(2) Colored / effect basecoat
(3) Colored 2K clearcoat
(4) 2K clearcoat

Here the effect-providing basecoat layer and a colored first clearcoat layer in addition to the basecoat / colored precoat enhance both the color tone and the optical effects. Finally, an

uncolored 2K clearcoat is applied. Thus, a very brilliant and intensive appearance of the painted surface is realized.

The technical details on the type and method of substrate pretreatment and further information can be found in the technical data sheets and documents of the refinishing system supplier and can be determined by using specially self-prepared color samples.

2.4.2. 4-Stage Colors With Three Basecoat Layers – Colored 3. Basecoat Layer (Transparent)

Topcoat build-up:

(1) Base color / precoat
(2) Colored / effect basecoat
(3) Transparent basecoat (colored)
(4) 2K clearcoat

Both the color tone and the optical effects are intensified here in addition to the base color / colored precoat by the effect-providing basecoat layer and a colored transparent basecoat layer. Finally, an uncolored 2K clearcoat is applied. Thus, a very brilliant and intensive perception of the painted surface is realized.

The technical details on the type and method of substrate pretreatment and further information can be found in the technical data sheets and documents of the refinishing system supplier and can be determined by using specially self-prepared color samples.

2.4.3. 4-Stage Paintings With Vacuum Metallic Pigments (VMP)

Topcoat build-up:

(1) Base color / colored precoat
(2) Transparent basecoat or 2K clearcoat with intermediate sanding
(3) Effect basecoat with Vacuum Metallic Pigments (VMP)
(4) 2K clearcoat

The visual effect is determined by the number of spray coats of the effect-providing basecoat. The visual appearance depends on the respective color shade and the surface condition of the substrate.

Vacuum metallic pigments have only a very low filling power; they are essentially used to create the effect. The finest impairments of the substrate (e.g. scratches / sanding marks, finest dust inclusions, etc.) therefore remain visible. For refinishing, it is essential to follow the instructions of the respective refinishing system supplier in order to be able to achieve the desired result in combination with a particularly careful working method.

The technical details on the type and method of substrate pretreatment and further information can be found in the technical data sheets and documents of the refinishing system supplier and can be determined by using specially self-prepared color samples.

2.5. Special And Custom Paintings

Special and custom paintings on vehicles can be applied at the factory in (low volume) production on the assembly line or at the special request of an individual customer or even afterwards by hand application.

In the area of the countlessly diverse special and custom paintings, the following paint finishes are most frequently found.

2.5.1. Paintings With Special Effect Color Pigments

Special effect paintings, also known as flip-flop, rainbow or fantasy color paintings, which contain a high proportion of interference pigments, can, in the event of damage, under certain circumstances only be repaired by painting a "visible surface" (e.g. the entire side of the car) or by painting the entire car.

It should be noted that single- or multi-coat solid and special-effect paints (metallic, pearl color, Xirallic®, multi-effect, other) in combination with different gloss levels (from high-gloss to very matte and textured matte) can also be classified as special-effect paints, and these are applied both by craftsmen and in the series production of car manufacturers. In the case of matte color shades, it is necessary to determine the gloss level and color shade based on self-painted color samples. Furthermore, in the case of matte color shades, as a rule only complete body parts can be painted. For refinishing, it is essential to follow the instructions of the respective refinishing system supplier.

2.5.2. Design Paintwork

The method of repairing design paintwork depends on the type and location of the damage and the design technique used. The efforts and costs of design paintwork must be evaluated separately in each individual case.

3. Color Tolerance According To DIN

The German Institute for Standardization (DIN), among others, has also dealt with the assessment of acceptable color tolerances in automotive construction and has published a new standard “DIN 6175:2019-07 Color tolerances for automotive coatings – Solid paintings and effect paintings“ on this subject.

For the damage practice and the assessment of repair paintwork of road vehicles with the questions arising there, among other things, about color measurement, color differences and color tolerances, this DIN standard cannot be reasonably applied due to the following aspects:

- The pure color tone is an important component of the visual impression, but this is influenced by other characteristics of the coating such as gloss, translucency and visual texture.
- Especially in the case of effect paintings, the visual impression is additionally co-determined by the distribution and orientation of the effect particles in the

basecoat layer. For this reason, visual evaluation or other measurement methods may be necessary in addition to color measurement for complete characterization of the painting.

- **Despite the use of digital spectrophotometers and other aids, the eye of the specialist is still required and essential for color matching in the repair stores.**

This document was decided unanimously on March 30, 2021 by the members of the German Commission for Paint and Bodywork Repair:

- Bundesverband der freiberuflichen und unabhängigen Sachverständigen für das Kraftfahrzeugwesen e.V. (BVSK)
- Bundesverband Farbe, Bundesfachgruppe Fahrzeuglackierer (BFL)
- Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV) sowie:
  Allianz Versicherungs-AG, Generali Deutschland AG
- Verband der Deutschen Lack- und Druckfarbenindustrie e.V. (VdL) – Arbeitskreis Autoreparaturlacke
- Verband der Automobilindustrie e.V. (VDA), vertreten durch:
  Bayerische Motoren Werke AG (BMW), MAN Truck & Bus SE, Opel Automobile GmbH, Volkswagen AG
- Verband der Internationalen Kraftfahrzeughersteller e.V. (VDIK) sowie:
  Honda Motor Europe Ltd, Renault Deutschland AG
- Verband der Technischen Überwachungs-Vereine e.V. (VdTÜV), vertreten durch:
  TÜV Süd AG
- Zentralverband Deutsches Kraftfahrzeuggewerbe e. V. (ZDK)
- Zentralverband Karosserie- und Fahrzeugtechnik e.V. (ZKF)
- AZT Automotive GmbH
- Autovista Group International AG / Schwacke GmbH
- DEKRA SE
- Deutsche Automobil Treuhand GmbH (DAT)
- IRS Holding GmbH / Hagelschadenzentrum Douteil GmbH
- Schaden-Schnell-Hilfe GmbH (SSH)
- Solera Holdings Inc. / Audatex AUTOonline GmbH