VDA | Verband der Automobilindustrie

16

Quality Management in the Automobile Industry

Decorative surfaces of external fittings and functional parts in the internal and externals of automobiles

Evaluation conditions
Definitions of characteristics and dealing with defects
Acceptance criteria

2nd. revised edition, 2008

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Translations

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VERBAND DER AUTOMOBILINDUSTRIE e. V. (VDA)

Contents Page

0 Preamble

It is expressly emphasized that this VDA volume does not represent a new surface specification for parts with surfaces which are judged by subjective evaluation.

This document must instead be regarded as a communication paper, to be used as a support in the essential exchange of views between customer and supplier, within the multi-lateral relationships in the various automotive supply chains, with regard to the features of the characteristics to be defined for the parts and process portfolio under consideration.

1 Objective / purpose

This VDA volume is intended to serve as an initial basis for bilateral negotiations between OEM and supplier, as well as between customer and supplier throughout the entire supply chain when agreeing a specification for the subjective characteristics of decorative surfaces. The results of such negotiations must then be recorded in individual contracts.

It also serves to provide a clear and unambiguous description of decorative product surfaces (so-called “subjective surfaces”) and to specify uniform test & inspection conditions, in order to prevent process problems for customers and suppliers because of imprecise or incomplete means of measurement.

For those involved in production processes this VDA volume serves as a training aid, to ensure that processes are applied in accordance with agreed references.

To avoid the extra costs and quality problems which might arise from a surface specification delayed until after SOP, the characteristics which are technically achievable must be presented as early as possible in the manufacturing feasibility analysis, as part of the project management process. The requirements should then be laid down in agreement with the customer, within the framework of advanced quality planning.

2 Area of application

This VDA volume applies to decorative surfaces of external fittings and functional parts in the internal and external areas of automobiles.

The area of application is defined as the visible area of the vehicle which is seen, whether standing or sitting, in the normal use of a vehicle.

3 Validity

The following types of products are primarily affected :

- Decorative strips, such as strips on handles, shaft coverings, frames, crash-bars and side-protection bars, radiator grills and decorative grids
- Panels (including mirrors)
- Covers in general

- Actuator elements, such as knobs, buttons, levers, switches, door-handles, air inlet nozzles
- Roof bars
- Luggage carriers (roof and tailgate systems
- Emblems, lettering and plates
- Mirror covers
- Fuel filler flaps
- Wood trim

Consideration is also given to parts and surface-related items. The material-specific characteristics of visible surfaces are dealt with in this VDA volume only where they do not exclude or contradict the standards typically employed in the automobile sector.

This VDA volume deals with the following manufacturing processes used to produce different surface finishes:

- Anodizing
- Powder coating (EPS)
- Wet painting
- Extrusion
- Plastic injection moulding
- Galvanizing
- Plasma procedures (evaporation, sputtering, CVD, PVD)
- Application techniques (adhesive/stamped decorative foils)
- Metal gravity die-casting
- Mechanical processing (e.g., grinding, polishing, deburring, drilling, milling, jointing)
- Laser lettering

No consideration is given in this VDA volume to any aspects of the colour assessment or colour metrology of painted external parts. For these the reader is referred to existing regulations issued by OEMs and various associations, as well as to international standards.

4 Evaluation zones

The types of evaluation zones must be specified in the component drawing and/or the data model.

The following table sets out a possible method of zoning for various components in terms of the significance or weighting of the defect.

ZONE	DEFINITION	ALLOCATION
A	Surfaces in the immediate line of sight	Exterior : The vehicle above the observer's waist line, extended if appropriate to describe a specific zone Interior : All parts in the direct line of sight of the persons in the vehicle
B	Surfaces not in the direct line of sight, or not seen in their normal position. Observation sector < 45°	Exterior : The vehicle below the observer's waist line, down to the level of the bumpers and any functional elements (open flaps, doors, etc.) Interior : All surfaces which are not immediately observable
Optional: C	Surfaces which are concealed following assembly	Surface has no relevance
Optional: D	Surfaces which have no significance in terms of surface coating but where the function prohibits certain surface characteristics	

Where concealed surfaces are concerned, the basic requirement is that functionality must not be affected.

5 Evaluation conditions

5.1 Position

The evaluation of the decorative parts must be made in accordance with the angle at which the part is installed and its position in or on the vehicle, or its normal functional position in relation to the main surface of the part, generally without reflection.

5.2 Lighting conditions

5.2.1 Brightness and colour temperature (exterior / interior)

The characteristics should be evaluated in normal daylight (from the north) or an equivalent artificial lighting source. Given the need for reproducibility of evaluations where disputes may arise, artificial light is preferred, subject to the following requirements :

- Lighting level of 1000 lux at the item under inspection
- A type 865 and 840 lamp should be used for evaluating the characteristics
- Lamp types 965 and 940 are also preferred for colour evaluation (in this connection see also the recommendations of the VDA colour metrology working group)

Lamp type	Colour temperature	Colour reflection index Ra
865 (cool daylight)	6500 K	85
840 (cool white)	4000 K	85
965 (cool daylight)	6500 K	93
940 (cool white)	3800 K	92

Explanation of
"colour reflection index"
(a term used in photometry)

This is a method of describing the influence of a light source on the colour effect of objects, by comparison with a reference light source having the same colour temperature. The colour reflection index serves as a quality characteristic between light sources of the same colour (metamer). The highest achievable value is 100.

Conventional fluorescent lamps have a value of 62. Fluorescent lamps with special phosphor compounds can achieve values of 80 and higher.

In the "daylight planning" the colour reflection index defines the spectral transmission performance of glasses or other transparent materials. In this context values of 95 or higher are regarded as acceptable.

The **general colour reflection index R_a** is a dimension describing the mean colour effect from 8 (eight) standardised colour samples. These samples will have been specified as a representative selection of colours from the chromatic or colour wheel with a medium saturation. If no specific comment is made regarding a given colour reflection index value, it may be assumed that the general colour reflection index is referred to.

NOTE

It must be borne in mind that certain characteristics cannot be detected under artificial light and others cannot be detected under natural light (see the table in Section 6). In such cases, individual arrangements should be specified on a contractual basis.

5.2.2 Lighting angle

In designing the layout of an inspection point and when carrying out a check at the point of manufacture, the artificial light source must be located ca. 120 cm vertically above the item under examination.

5.2.3 Orientation of the light source

In the event of a dispute and where fluorescent tubes are used, these must be positioned parallel to the longitudinal axis of the vehicle.

5.3 Observation distance

If no optical aid is used when assessing a product, the inspector should normally be ca. 50 to 70 cm from the object (an arm's length).

5.4 Observation period

When evaluating the quality position, the period of observation will depend on the evaluation zone.

Dependency on the surface must not be linear. In practice it has been seen that the formula $20\,\mathrm{sec} \times \sqrt{\mathrm{surface\_in\_dm^2}}$ relates close to real conditions, where the surface under examination is not merely a coated surface but is to be evaluated as an "A" or "B" surface. In such cases, cut-outs, windows, etc. must not be deducted from the surface under examination.

When specifying for a concrete product spectrum it is wise to lay down the surface-related observation period in terms of seconds.

Examples of practice-related observation periods are given in Section 10.3.

5.5 Target agreements

5.5.1 ppm and degree of validity

With good delivery quality, very few defects occur and these are measured in ppm (parts per million). In such situations it is sensible to agree on a zero-defect target. However, in mathematically physical terms this is an objective which can only be approached – and, furthermore, it can be approached from one side only. Practice has shown that it is advantageous to set intermediate targets in this process. If targets of this kind are used in order to evaluate delivery quality, the manufacturer and customer should agree the following :

- The defect level, for example in ppm
- The degree of validity (in terms of characteristics or a time period, including the guarantee period, special deliveries, etc.).

5.5.2. Quality position

The customer is generally not so much interested in the quality position as the percentage of defective items he receives. It is therefore sensible to use this figure in any agreements and for the customer to be aware that there are other influences to be taken into account, such as the human factor where subjective evaluations are involved.

The ability to detect structures and characteristics in the course of a visual examination and, therefore, the reliability of the inspection decisions which are taken, depends not only on the physiological resolution capability of the human eye but also on a wide number of other parameters.

Essential requirements for achieving positive, reproducible inspection results are normal vision at close quarters, good lighting conditions and no negative mental influences. The minimum requirement for inspection personnel dealing with characteristics to be judged on a subjective basis must therefore be a periodic check on normal vision at close quarters.

Decisions made regarding characteristics evaluated subjectively can therefore be compared only under strictly defined conditions.

Thus, the ability to differentiate (the discrimination characteristic) when making visual quality checks must be subject to a convention representing the unavoidable percentage of defective parts which slip through the evaluation. For the area of application covered by this present VDA volume this percentage $\mathbf{P_D}$ has been set at

$\mathbf{P_D = 0.003}$ which is the equivalent of **0.3%**.

For this percentage of the batch it is **not** possible to differentiate between defective and defect-free parts and this means that defective parts will not be detected (in this context, "defective parts" are parts which can be detected as having deviations which exceed the tolerances set out in this specification).

5.5.3 Determining the quality position

The base reference for this is the actual number of parts in the batch which deviate from the specification. This quantity must be specified appropriately and the P_D quota must be taken into account by both parties.

If the batch is evaluated on the basis of the number of defective units in the random sample, the confidence level (for example, 95 %) must also be taken into account.

In this case the size of the random sample '**n**' must be the same as the quantity which has been delivered, since the proportion of defective parts generally taken into account on the assembly line will have taken into account all the parts which have been shipped.

5.5.4 Special ppm agreements

Specially agreed defect levels may have an effect on costs and these should be covered in contracts setting out the supplementary stipulations.

5.6 Ensuring the comparability of inspectors and inspection requirements - aligning the evaluation standard

In the wake of increased requirements relating to optical characteristics, it is even more important, both for the supplier and the customer, to align their evaluations and the standards used.

In doing so it is necessary to establish an objective basis as a starting point for discussion in determining the procedure to be applied. A proven method is the so-called "attributive gauge R & R" procedure. Attributive data are values which can be classified as "yes/no" and "gauge R & R" describes an analysis of the measurement system. Here, "R & R" stand for reproducibility (where different people use the one measurement device) and repeatability (where one person uses one device to make the same check more than once). Stated briefly, it is a kind of information check, designed to ensure that the decisions taken by a single inspector, as well as those taken by several different inspectors, are reproducible, particularly in regard to the customer's standard. Thus, this procedure investigates the main influences in deciding on the acceptance or rejection of parts which are to be visually evaluated.

A study of this kind is established as follows :

- Firstly, a binding standard – for example, master reference parts – must be agreed with the customer. The reference parts are then be identified using consecutive numbers. The reference parts themselves will cover the entire decision-making spectrum, ranging from fully-acceptable parts, through border-line cases to parts which can clearly be identified as unacceptable. A table is drawn up (Fig. 1), in which the part numbers and the decisions are recorded. It is important that the inspectors who will later carry out the checks do not have access to this information, so that their results will not be influenced.

Known Population		Operator #1		Operator #2		Operator #3		Y/N	Y/N
Sample #	Attribute	Try #1	Try #2	Try #1	Try #2	Try #1	Try #2	Agree	Agree
1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Y	Y
2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Y	Y
3	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Y	Y
4	Pass	Pass	Pass	Pass	Pass	Fail	Pass	N	N
5	Fail	Fail	Fail	Fail	Fail	Pass	Fail	N	N
6	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Y	N
7	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Y	Y
8	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Y	Y
9	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Y	Y
10	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Y	Y

Fig. 1 : Attribute gauge R & R effectiveness

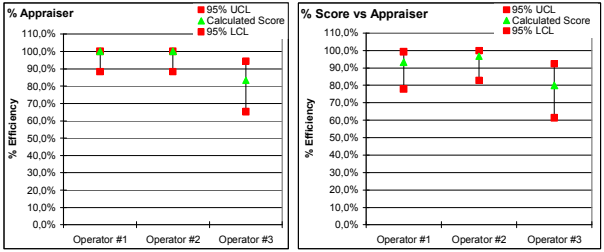
- These parts are then given to the inspectors in a completely random sequence and they must make their decisions within a normal time for evaluation. These decisions are then entered in the table. Each inspector must make two checks on all the parts.

- The results can then be evaluated against the relevant criteria, which in this case are :
  - the degree of consistency of the two assessments made by each inspector
  - the degree of consistency of the assessments made by each inspector against the standard
  - the degree of agreement between the various inspectors
  - the degree of agreement between the various inspectors by reference to the standard

DATE: 4.1.2001
NAME: Acme Employee
PRODUCT: Widgets
BUSINESS: Earth Products

Source	% Appraiser[1] Operator #1	Operator #2	Operator #3	%Score vs Attribute[2] Operator #1	Operator #2	Operator #3
Total Inspected	30	30	30	30	30	30
# Matched	30	30	25	28	29	24
False Negative (operator rejected good product)				1	0	0
False Positive (operator accepted bad product)				1	1	1
Mixed				0	0	5
95% UCL	100,0%	100,0%	94,4%	99,2%	99,9%	92,3%
Calculated Score	**100,0%**	**100,0%**	**83,3%**	**93,3%**	**96,7%**	**80,0%**
95% LCL	88,4%	88,4%	65,3%	77,9%	82,8%	61,4%

	Screen % Effective Score[3]	Screen % Effective Score vs Attribute[4]
Total Inspected	30	30
# in Agreement	24	23
95% UCL	92,3%	90,1%
Calculated Score	**80,0%**	**76,7%**
95% LCL	61,4%	57,7%



Notes

(1) Operator agrees with him/herself on both trials
(2) Operator agrees on both trials with the known standard
(3) All operators agreed within and between themselves
(4) All operators agreed within & between themselves AND agreed with the known standard

Fig.2 : Statistical Report – Attribute gauge R&R study

What can be deduced from Fig. 2 ?

The so-called "Calculate Score" states the mean value for consistency between the inspectors. This should be at least 80%. The "Score versus Appraiser" indicates how consistent the individual inspector is in his/her decisions.

The following actions can now be derived from these statistics :

- If the inspectors are able to identify the standard with a consistency of at least 80%, the limit samples may be regarded as established and fit for purpose. If the figure is lower than 80% discussions must be held with the customer to agree on methods (for example by reducing the requirement level) to make it possible to identify the characteristics more easily,.

- If one inspector has a problem in reaching a reproducible decision, training can be carried out until he/she achieves 80% consistency with the customer standard.

The enclosed CD contains an evaluation file to enable an attributive gauge R&R study to be carried out.

5.7 Handling samples from a process at maximum tolerance limits (MTP samples) and limit samples

Where the acceptable quality agreed with the customer refers to characteristics with tolerances which cannot be physically measured, acceptable quality is defined by samples representing the maximum tolerance limits of the process. These so-called **MTP samples** define the quality limits agreed with the customer and are the equivalent of the upper and lower tolerance limits for characteristics which can be measured. Thus they represent the normal distribution of characteristics within a full industrial production process.

Within the terms of this definition, therefore, limit samples are sample parts which define an extension of these tolerance limits beyond the specified upper and lower tolerance limits and thus illustrate the range of characteristics which can still be accepted in border-line cases without causing any impairment for the end-customer.

The customer's agreement can be recorded either by the customer's signature on the part itself, or a record can be made in the limit sample agreement process, referring to the MTP sample and/or limit samples. Alternatively an internal signature may be sufficient, following verbal agreement with the customer's authorized representative (the name of the person and the date of agreement should also be recorded).

All MTP samples and limit samples recorded in the production control plan must be included in the test/inspection equipment monitoring system so that their point of use, their storage location and their period of validity are traceable. In this way it is ensured that they are checked at periodic intervals to confirm that they are still in order and correspond with the current quality requirements.

Only in this manner can they be used as a reproducible basis for a contract.

MTP samples and limit samples are also used for training purposes or can be duplicated and displayed as border-line samples at the work-place (the duplicates must be faithfully generated from the official limit samples and MTP samples).

Any further deviation from the surface specifications defined in the contract must be recorded in the form of special approvals for a limited period, in accordance with the customer's current requirements, with a reference to the QM system.

Wherever practical, MTP samples should be specified and agreed as early as possible in a project phase. Here, in the earliest stages, samples of characteristics from comparable processes with parts having a similar geometry can be used as an initial basis. These must be replaced as parts become available from the original process.

Within a multiple-stage supply chain it may be necessary, in order to establish a clearly defined quality acceptance level between the customer and supplier, to agree the MTP samples in stages and classifications. In such cases it is important that the originating customer specifies clear requirements for acceptable OK characteristics relating to the surface process to be provided. These characteristics must then be faithfully duplicated and firmly agreed throughout the entire supply chain.

MTP samples can be divided into different classifications :

- **MTP samples, Class C :** agreed between the direct customer and his originating surface process supplier
- **MTP samples, Class B :** agreed between the supplier of the part with the surface treatment and the Tier "n" supplier in the supply chain
- **MTP samples, Class A :** agreed between the Tier "n" supplier and the OEM.

Ideally, MTP samples to Class A are the best alternative for the entire supply chain, because these provide decided clarity for the entire supply chain, through to the OEM, regarding the quality position for characteristics judged on a subjective basis.

If it is not possible to agree on Class A samples, for no matter what reason, the objective for the originating surface process supplier should always be to achieve MTP samples to Class B (agreement with the Tier "n" supplier in the supply chain). Class C samples are absolutely essential for a regulated and fully controlled manufacturing process.

6 Defining characteristics / addressing defects

No.	Type of characteristic	Process allocation *)	Definition
1	Offset	5, 8, 12,13,15	Misalignment where parts are structured (for example, by vulcanisation or over-moulding)
2	Burn marks	1, 6	Matt / crumbly appearance to surface, caused by dendritic separation in the limit current area (referred to as "buds" when they are large)
3	Dents	6, 8 – 16	Flat bubble-like depressions, caused by high pressure
4.a 4.b	Bubbles Pitting	2, 3, 6, 7, 13 2, 3, 6, 7, 13	a) Generally round, even protrusions (hollow inside) b) Generally circular, crater-like depressions in the top coats or intermediate coats. Typified by raised edges
5	Impression marks	6, 8, 9, 10, 12, 13, 16	Irregularly distributed, slight spots or depressions to the surface, over very limited areas, caused by the compression of foreign bodies.
6	Anodising splits	1	Micro-splits : small, linear features in the anodising coating, caused by excessive local deformation of the component or excessive coating build-up during anodizing
7	Colour misting	3, 13	Fine, dust-like paint particles on the surface, not distributed in a homogenous manner in the paint film; drop-like paint particles distributed over the paint film
8	Colour differences	2, 3, 6, 13	Colour deviation on a surface by comparison with the neighbouring surface or reference sample. This results from : (a) materials (b) process (c) subjective impression : saturation; brightness; purity; level of sheen; depth; surface structure.
9	Swollen edges	2, 3, 6, 13	A thickening of paint coatings (bulging) on edges of components, such as are caused by surface tensions. The effect correlates primarily with the edge radius and/or the position of the component during the process
10	Flecks	1, 2, 3, 6, 7, 13	Sharply delineated, local dulling of the surface, caused for example, by dirt / corrosion in spots or larger areas, or drying flecks

No.	Type of characteristic	Process allocation *)	Definition
11	Flash on tool split line	5, 6, 13	Flash which can occur where there is an unavoidable mismatch between parts of a tool or sliders (e.g., plastic residues on injection-moulded parts). Can also be caused by wear and overflows
12	Differences in sheen	1, 3, 6, 7, 13	The sheen (or gloss) differs from that of the (master) sample on some areas or over complete surfaces
13	Flash / burrs	2, 3, 5, 8, 15	Sharp-edged projection of edge zones from earlier process (e.g., stamping burrs on cut edges; flash on plastic mouldings; paint grit)
14	Grittiness	1, 3, 6	Visual (optical) effect which can occur by diffuse reflection on interfaces between different structures (e.g., etched granularity)
15	Hairline splits	3, 6, 10, 13	Extremely fine lines of damage
16	Contact/gripping points (caused by the process)	1, 2, 6, 7	Small areas, usually as spots where paint / coating is missing (in an area not normally visible), caused by suspension clamps, contact with painting frames, etc.)
17	Scratches	5, 6, 8, 10, 13, 16	Lines of damage, caused by inappropriate handling.(e.g., when removing parts from the tool)
18	Paint runs	2, 3, 13	Tracks of paint in the top coat or in an undercoat, on vertical surfaces (generally in the vicinity of grooves, rounded sections, folds or piercings)
19	Lens-like paint marks	2, 3, 13	Distortion in paint surface which can be seen but not felt : paint runs / streaks in the early stages
20	Thin coating areas	2, 3, 7, 13	Inadequate top coating (the substrate can be seen through the surface coating)
21	Macro-splits	1, 6	Splits in the galvanic coating, caused by deformation
22	Pin-holes	2, 3, 6, 7, 13	Very small cratering (see 4b above); also micro-pores
23	Nickel patches	6	Yellowish places in the contact area and in areas where the current density is low

No.	Type of characteristic	Process allocation*)	Definition
24	"Orange-peel" effect	2, 3, 6, 13	A rough or wave-like appearance of a painted surface which may contain a texture; a grained paint finish with the structure of an orange peel
25	Oxide lines	11	These are streaks caused by oxide inclusions and/or oxide lines. They are pencil-like, white or grey lines in the direction in which the part was formed. The degree of visibility depends on the type and quantity of oxide inclusions.
26	Pimpling / inclusions	1 – 7, 15	Contamination within the surface, such as dust or fluff, which protrudes in some areas through the coating or growths causing problems in the build-up of coats
27	Pigmentation problems	2, 3	Disorientation of pigments (e.g., metal flakes).
28	Various polishing defects	6, 9, 13, 16	Collective category for defects not often encountered / which form a small percentage of defects
28.a	Stippling		Polygonal, flecked areas caused by material residues which have been polished in.
28.b	Dull areas		These occur following electrolytic sheening and are caused by excessive local heating; also surfaces areas which have not been sufficiently polished.
28.c	Holograms		Polishing defects with a 3-dimensional effect. These occur particularly with dark paint colours.
28.d	Polishing flecks		Restricted circular areas with a much smoother surface than the surroundings
29	Polishing "fish" / "comet tails"	6, 9, 11, 13	Depressions in a shape similar to that of a fish, caused during the polishing process by a foreign body, a pore or other pre-conditioning from earlier processes, such as grinding.
30	Polishing streaks	6, 9, 13, 16	Very fine, localised raising of visible ribs, caused by the polishing process (incorrect polishing paste and / or disc was used)
31	Pores	2, 3, 6, 13, 15	Small holes, visible with the naked eye, in the top coating

No.	Type of characteristic	Process allocation*)	Definition
32	Indications of seams / seam-welds	4, 8	These are traces of longitudinal lines, caused by extrusion presses, welding operations, etc. They are (narrow) streaks, running in the direction in which the part was formed, where the area is seen as lighter or darker than the surrounding material, depending on lighting conditions. They can also occur in association with sink-marks or step-marks. Indications of longitudinal seam / seam-welds are caused by manufacturing processes and are unavoidable; however, the level of their appearance can be influenced
33	Scour marks	6, 10, 13, 15	Flat, local roughing of the surface, generally seen as differences in levels of sheen
35	Striations	8, 11	Liquation streaks with an electro-potentiostatic effect, caused by pre-treatment for anodising and resulting from liquation in the incoming material
36	Graininess	6	Slight graininess of a galvanised surface; comparable with the "orange peel" appearance on painted surfaces
37	Corrugations	6, 8, 9, 11, 13, 16	Wave-like, parallel marks on the surface of the panel or profile, at an angle to the direction of rolling or compression, which can be seen in special observation positions (e.g., looking in the rear-view mirror, reflection in a longitudinal direction at a very shallow angle of observation)
38a	Cloudiness/ fogging/ streaks	9, 13	Local areas which are matt, dull, cloudy or streaky, with diffuse transfer between different areas.
		3	When painting : noticeable, partially light or dark areas within a (metallic) paint finish with diffuse transfer from one area to the next.
		6, 7, 13	Dull areas within the overall surface; with diffuse transfer from one area to the next
38b	Streaks caused by moisture / air	9, 12	These occur during plastic injection moulding and are caused by moisture in the plastic or air inclusions during the injection moulding process.

No.	Type of characteristic	Process allocation*)	Definition
39	Differences in coating thicknesses	2, 3, 6	These occur during galvanizing as a result of inappropriate current density distribution (6) or in other processes because of different particulate flows / flow angles or separation conditions
40	Sink marks	6, 12, 13, 15	Visible dents in the surface, caused by elements on the other side of the component, such as ribs, steps and domes (6). Dents in the surface, caused by inappropriate component geometry and / or shrinkage (12).
41	Converging flow marks	6, 13, 15	Visible scratch-like flow-marks on plastic parts where flow fronts converge.
42	Sucker marks	3, 6, 12, 15, 16	The result of contact between the surface and rubber suckers. They are visible marks, caused by sucker deposits when removing the part following the process
43	Seam welds	12, 13, 15	These occur at the convergence of two mass flows after piercings and domes (converging seam weld)
44	Moisture inclusions	2, 5, 12, 13	Damp material not correctly prepared. Expanding moisture is deposited as streaks or bubbles on the surface of the article
45	Holes	6	Holes in the surface coating, visible with the naked eye, penetrating to the base material
46a	Alignment gap	13	Caused by inaccurate alignment of veneers / a line is visible.
46b	Alignment offset	13	Caused by inaccurate alignment of veneer / an offset in structural symmetry
47	Patch marks	13	Caused by voids, holes and splits
48	Jagged knife edges	13	Damage caused by a knife when peeling / deburring the component
49	Differences in structure and texture	13	Uneven structure. Branches and bars not adequately formed. This occurs in nature.

No.	Type of characteristic	Process allocation*)	Definition
50	Compressed folds	13	Visible lines; overlapping materials.
51	Paint residues	17	Parts of the surface have not been removed by the laser process
52	Burn marks	5, 17	Thermal changes in the plastic substrate (changes in colour)

*) **Process allocation**

- 1) Anodizing
- 2) Powder coating (EPS)
- 3) Wet painting
- 4) Extrusion
- 5) Injection moulding
- 6) Galvanizing
- 7) Plasma process (evaporation, sputter, CVD, PVD)
- 8) Over-moulding
- 9) Polishing
- 10) Assembly / packaging / handling
- 11) Incoming material
- 12) Plastic processing
- 13) Refined wood surfaces
- 14) Application technology (gluing insert foils, embossing decorative foils)
- 15) Metal die-casting
- 16) Mechanical processing (grinding, polishing, deburring, drilling, milling, insertion, etc.)
- 17) Laser lettering

7 Acceptance criteria

The maximum tolerances achievable under full production conditions should be specified for the product-related characteristics defined in Section 6 above. Ideally, this should take the form of a bilateral agreement process between customer and supplier, if possible before estimates are drawn up and quotations issued.

7.1 Acceptable characteristics

Examples of acceptable characteristics are set out in the table in Section 10.1

7.2 Quantifiable characteristics

7.2.1 Classification

Examples of qualitative characteristics are set out in the table in Section 10.2.1.

7.2.2 Permitted density / frequency

Examples of quantifiable characteristics are set out in the table in Section 10.2.1.

8 Evaluation method

Any inadequacies detected within the observation period should be compared with the acceptance criteria.

If there is any doubt, the surface should be examined with a magnifying glass with a magnification of x 8 -10.

9 Miscellaneous

In order to achieve the acceptance criteria set out in Section 7, this specification should be taken into consideration in the sourcing process for semi-finished products and accessory parts, as well as suppliers of surface-finish items, in order to define requirements at the appropriate time, particularly with regard to semi-finished products.

10 Appendix

The measurable characteristics set out in this appendix represent the characteristics which are economically achievable under full production conditions with the present state of technology. Where appropriate (and depending on the product) they should therefore be taken as a basis for initial calculations and may form the basis for individual ppm agreements covering pre-production and full production.

10.1 Table of examples of acceptable characteristics

No.	Type of characteristic	Process allocation *)	Zone A	Zone B
1	Offset	5, 8, 12, 13, 15	Visible & detectable by touch : ± 0.3 mm	± 0.7 mm
2	Burn marks	1, 6	Limit sample	Limit sample
3	Dents	6, 8 - 16	Not acceptable if visible at a distance of ≥ 800 mm	Not acceptable if visible at a distance of ≥ 1200 mm
4 a	Bubbles	2, 3, 6, 7, 13	Limit sample	Limit sample
4 b	Pitting	2, 3, 6, 7, 13	Limit sample	Limit sample
5	Impression marks	6, 8, 9, 10, 12, 13, 16	d ≤ 0.7 mm . Max. 2 impressions at a spacing of 400 mm	d ≤ 1.0 mm . Max. 4 impressions at a spacing of 300 mm
6	Anodizing splits	1	Limit sample	Limit sample
7	Misting paint	3, 13	Limit sample	Acceptable
8	Differences in colour tone	2, 3, 6, 13	Deviation as limit sample	Limit sample
9	Swollen edges	2, 3, 6, 13	Limit sample	Acceptable
10	Flecks	1, 2, 3, 6, 7, 13	Not acceptable	Not acceptable
11	Flash on tool split line	5, 6, 13	max. +0.3 mm	max. 0.5 mm
12	Differences in sheen	1, 3, 6, 7, 13	Limit sample	Limit sample
13	Flash / burrs	2, 3, 5, 8, 15	Limit sample	Limit sample
14	Grittiness	1, 3, 6	Limit sample	Limit sample
15	Hairline splits	3, 6, 10, 13	Limit sample	Limit sample

No.	Type of characteristic	Process allocation*)	Zone A	Zone B
16	Contact / gripping points (caused by the process)	1, 2, 6, 7	Limit sample	Limit sample
17	Scratches / scoring (longitudinal)	5, 6, 8, 10, 13, 16	L ≤ 4 mm, B ≤ 0.5 mm. Max. 2 scratches at a spacing of 300 mm	L ≤ 10 mm, B ≤ 0.7 mm. Max. 4 scratches at a spacing of 200 mm
17	Scratches / scoring (lateral)	5, 6, 8, 10, 13, 16	Not acceptable	Not acceptable
18	Paint runs	2, 3, 13	Not acceptable	Acceptable
19	Lens-shaped paint marks	2, 3, 13	Limit sample	Limit sample
20	Thin paint / coating	2, 3, 7, 13	Not acceptable	Limit sample
21	Macro-splits	1, 6	Limit sample	Limit sample
22	Pin-holes	2, 3, 6, 7, 13	Accumulation of ≤ 5 pin-holes over 4 cm^2 is permitted	Pin-holes are acceptable
23	Nickel patches	6	Limit sample	Limit sample
24	Orange peel	2, 3, 6, 13	Fine structure permitted, as limit sample for appearance and percentage of total surface area	Coarse structure permitted, as limit sample for appearance and percentage of total surface area
25	Oxide lines	11	Structures visible at ≥ 800 mm are not acceptable	Structures visible at ≥ 1200 mm are not acceptable
26	Pimpling / inclusions	1 – 7, 15	See Section 10.2	See Section 10.2
27	Pigmentation problem	2, 3	Limit sample	Limit sample
28	Various polishing defects	6, 9, 13, 16	Not acceptable if visible at a distance of ≥ 800 mm	Not acceptable if visible at a distance of ≥ 1200 mm
29	Fish-shape / comet tail from polishing	6, 9, 11, 13	T ≤ 0.3 mm, B ≤ 2.5 mm, L ≤ 5 mm. Max. 2 within a spacing of 400 mm	T ≤ 0.5 mm, B ≤ 3 mm, L ≤ 8 mm. Max. 4 within a spacing of 300 mm
30	Polishing streaks	6, 9, 13, 16	L ≤ 60 mm B ≤ 0.5 mm Max. 6 within a spacing of 300 mm	L ≤ 80 mm B ≤ 3 mm Max. 10 within a spacing of 200 mm

No.	Type of characteristic	Process allocation*)	Zone A	Zone B
31	Pores	2, 3, 6, 13, 15	See Section 10.2	See section 10.2
32	Compression seam marks	4, 8	Limit sample	Limit sample
33	Scour marks	6, 10, 13, 15	Not acceptable	Limit sample
34	Linear marks (steps; pitting from rolling)	4, 6, 8, 15	Not acceptable if visible at a distance of ≥ 800 mm	Not acceptable if visible at a distance of ≥ 1200 mm
35	Striations; streaks	8, 11	Limit sample	Limit sample
36	Changes in layers	6	Limit sample	Limit sample
37	Corrugations	6, 8, 9, 11, 13, 16	Not permitted under the following conditions : - item in the installed position - artificial light-source 1.2 m above the item being checked; - inspector 2.5 ± 0.5 m from the item being checked; - viewed at 20° to 45° to the longitudinal axis of the vehicle with static observation	Not acceptable if visible at a distance of ≥ 4 metres, if evaluated as for Zone A
38	Cloudiness / smears	3, 6, 7, 9, 13	Limit sample	Limit sample
39	Fluctuations in coating thicknesses	2, 3, 6	Limit sample	Limit sample
40	Sink marks	6, 12, 13, 15	Limit sample	Limit sample
41	Converging flow marks	6, 13, 15	Limit sample	Limit sample
42	Sucker marks	3, 6, 12, 15, 16	Limit sample	Limit sample
43	Seam welds	12, 13, 15	Limit sample	Limit sample
44	Moisture inclusions	2, 5,12, 13	Not acceptable	Limit sample
45	Holes	6	Limit sample	Limit sample

No.	Type of characteristic	Process allocation *)	Zone A	Zone B
46a	Alignment gap	13	Limit sample	Acceptable
46b	Alignment offset	13	Limit sample	Acceptable
47	Patch marks	13	Limit sample	Acceptable
48	Jagged knife edges	13	Not acceptable	Limit sample
49	Differences in structure and texture	13	Limit sample	Acceptable
50	Compressed folds	13	Limit sample	Acceptable
51	Paint residues	17	Not acceptable	Limit sample
52	Burn marks	5, 17	Limit sample	Limit sample

*) **Process allocation**

- 1) Anodizing
- 2) Powder coating (EPS)
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- 17) Laser lettering

10.2 Table of example of quantifiable characteristics to Table 10.1

10.2.1 Examples of classification by size and permitted frequency

Maximum permitted total number of characteristics for a single reference surface :

Size	Limits	Frequency in Zone A	Frequency in Zone B
Large	> 0.5 mm to 0.8 mm	1	2
Medium	0.3 mm to ≤ 0.5 mm	2	4
Small	< 0.3 mm	4	No restriction

10.2.2 Example of classification by minimum distance between individual defects

Characteristics extending no more than 0.4 mm in any direction are not evaluated. Accumulations of more than 2 defects per 25 cm² are not permitted.

In Zone A two defects are permitted, provided they extend no more than 0.5 mm and they are more than 200 mm apart.

In Zone B two defects are permitted, provided they extend no more than 0.75 mm and they are more than 100 mm apart.

If the product under examination is smaller than an enclosed circle of 200 mm the following restriction applies :

Zone A:

- max. 2 defects extending no more than 0.5 mm in any direction, for surface areas up to 25 mm²
- max. 3 defects extending no more than 0.5 mm in any direction, for surface areas up to 25 mm²

Zone B:

- max. 2 defects extending no more than 0.7 mm in any direction, for surface areas up to 25 mm²
- max. 3 defects extending no more than 0.7 mm in any direction, for surface areas up to 25 mm²

10.3 Table of examples of practice-related observation periods

Logos (small)	5 sec.
GWS panels	10 sec.
Front panels	15 sec.
Gear clips	10 sec.
Chrome rings	5 sec.
Filler pieces	5 sec.
Exterior mirrors	20 to 30 sec., depending on complexity
Trim strips	15 sec.

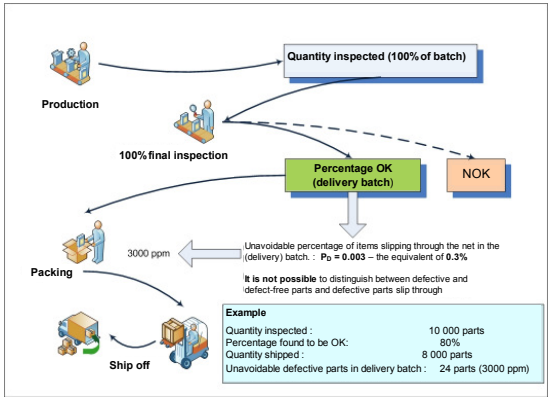
The following must be borne in mind when carrying out checks in full production :

- Always examine the part in its installed position
- Prevent any reflection from the part
- The aim is not to seek defective characteristics. Only those characteristics recognized as outside the specified limits and MTP samples are to be evaluated as defective.

10.4 Example of a ppm calculation, taking account of items which slip through

When dealing with the question of items which "slip through the net" and the percentages involved (see Section 5.5.2) discussion will always arise in practice. Because of this, an example is provided here to explain the minimum percentage levels involved. This gives concrete figures in illustrating the possible (unavoidable) percentage of defective parts in a delivery batch.

The illustration takes a practical example, with figures, to show what part-quantities of a production batch or delivery batch in calculating the associated ppm figures.



10.5 Pictures to aid discussion of characteristics

See enclosed CD-ROM.

10.6 Attributive gauge R & R effectiveness

The enclosed CD-ROM contains an executable EXCEL file with a demonstration program, to carry out an attributive check of this kind, covering the comparability of inspectors and inspection checks in accordance with Section 5.6 where parts with surfaces are judged on subjective terms.

11 Bibliography

The following research papers and reports should be taken into account when drawing up a specification. These contain references to other literature.

- Heinz Schmidke : "The ergonomics manual" (chapter dealing with workloads and stresses). Section 3.5 : "Problems with Wakefulness".
- Prof. Dr. med. E. Grandjean : Physiological work-place layouts. Section 9.3 : "Long-term attentiveness".
- Dr. phil. Martin Schütte : "Visual quality checking and mental stresses".
- DIN EN ISO 8785 : "Surface imperfections".
- KU-Marketing, Europa/VAT, Bayer AG, Leverkusen : "Injection moulding – defects, causes and solutions".
- IWK RWTH Aachen : "Characteristics of aluminium extruded profiles". In-house publication, 2001.
- DGM : "Lists of defects in extrusion presses" (AK Leichtmetall).
- Working committee for metal castings at the FH Aalen : "List of defects in zinc pressure die castings", ISBN 3-932291-12-3.

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