Explanatory notes

Scope

These Explanatory notes describe and explain the fields in Hempel's Product Data Sheets (PDS) to ease the understanding of the data provided.

The notes explain the content of each field, provide background information and state any definitions, standards and measurement methods that may be of relevance during planning and application of Hempel's products.

The reader should be aware that data, directions and recommendations given in the PDS are based on test results or experience obtained under controlled or specifically defined circumstances. Their accuracy, completeness or appropriateness under operational conditions may be different.

Product characteristics

Description
A short description of the product with emphasis on generic type, functionality, basic chemistry, principal properties, advantages and certain limitations.

Recommended use
The usage for which the product is designed or particularly well suited. The product may be specified for other uses in tailor-made paint systems as outlined in the specification.

Service temperature
The maximum (and minimum) temperature that will have no immediate detrimental effect on the paint.

A service temperature constantly near the maximum value will result in a shorter service life of the specified paint system compared to the same paint system operating at temperatures in the middle of the range. If the service temperature often fluctuates between mid-range temperatures and a temperature close to the maximum value, accelerated ageing (a decrease in the paint system's anticipated service life) is to be expected.

Most paints will change appearance when exposed to high temperatures, either by changing colour and/or losing gloss. In addition, many paints will become soft at high temperatures and show higher sensitivity to mechanical or chemical actions.

Exposure to warm liquids, including water, is normally only recommended for dedicated paint systems. At high temperatures, wet service will have a more pronounced influence on service life than dry service.

When a paint system is exposed to fluctuations in temperature, wet service conditions will induce more stress than dry service conditions at the same temperature. If the liquid has a higher temperature than the coated steel, a 'cold wall' effect will increase the risk of blistering and put further limitations on the paint system's temperature resistance. Most paint systems only tolerate very low negative temperature gradients under wet/immersed service conditions.

Certificates/approvals
A list of key certificates and approvals. Other certificates and approvals may be available from Hempel on request.

Features
A summary of the most important product features.

Product safety

Flash point
The lowest temperature at which a liquid liberates sufficient vapour to form a mixture with the air near its surface which, if ignited, will make a small flash, but not catch fire. It is important to note that adding thinner to a paint may change the flash point of the diluted material.

The flash point of Hempel's paints are measured using the Setaflash method (closed cup) according to ISO 3680:1983. For multi-component products, the flash point of the mixed product is shown. The flash point of the individual components is stated in the Safety Data Sheet for the specific quality and shade.

VOC content
The calculated or measured weight of volatile organic compounds (VOC) in grams per litre (and, in some cases, lb per US gallon). For multi-component products, the VOC is stated for the mixed product and, for certain paints, also for the diluted material according to EU Directive 2004/42/CE or other legislation.

VOC refers to chemical compounds that, because of their high vapour pressure and low water solubility, easily evaporate and change from liquid phase to gas phase. For paints, there is no global definition of which chemical compounds constitute VOCs, hence different VOC legislations are applicable around the globe.

At Hempel, the VOC content of a paint formulation is determined by calculation rather than measurement. All of Hempel's products are manufactured using a controlled formulation. To calculate the VOC content of the final product, the paint formulation is broken down to substance level.

Since VOC status differs for some substances under different legislations, the VOC content shown in the PDS is calculated according to one or more of the following legislations: EU, US,

Korea, China, Hong Kong or Canada. If you require the VOC content under a specific legislation that is not shown in the PDS, please request the value from Hempel.

In some cases, the PDS will show a measured VOC value instead of calculated value. In those cases, the measurement method will be stated. More detailed information on VOCs for specific components is given in the Safety Data Sheets.

Handling
General safety precautions that should be taken when handling or working with the product. For detailed safety information, please see the product's safety label and Safety Data Sheet.

A product declared 'for professional use only' must only be applied by trained applicators.

Product data

Product code
The product's unique 5-character code. A multi-component product will have a product code, as well as a code for each component (see below).

Product components
The unique 5-character code for each component in a multi-component product. This field is not shown in a PDS for a one-component product.

Standard shade/code
The shade/colour written as a 5-character code. Hempel's paint colours each have a different code. The code number range for the colour groups is shown below.

Colour groups	Hempel code
White	10000
Whitish, grey	10010-19980
Black	19990
Yellow, cream, buff	20010-29990
Blue, violet	30010-39990
Green	40010-49990
Red, orange, pink	50010-59990
Brown	60010-69990

Hempel's standard shade codes do not correlate directly to official standard colour codes, but please ask Hempel for more information on conversion of shade codes. Frequently used colours/shades are displayed on Hempel's colour cards.

The fifth character in the code may be used to identify specific formulas for the same shade when a different type of pigment is used (for example, to conform to specific standards or local legislation).

Please note that shade variations may occur in products in which colour is of less importance, such as primers, many intermediates and antifoulings. Uniform appearance of a topcoat is best obtained by applying paint with the same batch numbers.

Certain physicochemical data may vary from one shade to another due to the colour-specific pigments. Occasionally, this is of relevance for VOC content, volume solids, specific gravity and film thickness for aluminium shades. Specific values are available from Hempel on request.

Gloss
The specular gloss of the paint film after drying under optimal conditions in the laboratory (non-metallic paints only). The measurement is performed according to ISO 2813:1994/Cor. 1:1997 with the reflectometer set at 60° geometry. The output figures are converted to text as follows: high gloss (>90), glossy (60-90), semi-gloss (30-60), semi-flat (15-30), flat (<15), silk (5-10) and matt (<5).

The actual gloss will depend on conditions during application, drying and curing. For the gloss of aluminium shades, please consult the technical guideline on gloss of aluminium pigmented coatings on hempel.com.

Volume solids
The volume solids (VS) value, written in percentage and expressing the ratio: dry film thickness / wet film thickness.

The stated value is determined under laboratory conditions according to ISO 3233-1:2012 after a drying period of 7 days at 23°C [73°F] and 50% relative humidity.

For 100% VS products the *theoretical* value is shown. This value is not reflected in the above ratio due to shrinkage during curing.

VS values are reported with an uncertainty range of up to 3 percentage points. This uncertainty takes into account the paint type, normal manufacturing tolerances, experimental uncertainty, etc. Please note that volume solids may vary with shade.

Specific gravity
The weight of the paint per unit volume at 25°C [77°F], expressed in kilograms per litre (and, in some cases, lb per US gallon). For multi-component products, the specific gravity is stated for the mixed product. The specific gravity of each component can be found in the Safety Data Sheet.

At Hempel, the specific gravity is calculated according to ASTM D 5965-02, Test method C. The actual specific gravity may vary with shade and by a few percent compared to the theoretical value shown in the PDS.

Reference dry film thickness
The dry film thickness (DFT) used when determining performance parameters, such as drying time and overcoating intervals. The reference DFT is often used as a starting point when setting the specification for a system.

DFTs are checked by the measurement methods described in the ISO 19840-2012 standard. When calibration is done on smooth reference panels, the measured DFT is corrected using

the correction values required by the standard. No correction values are used when calibration is done on the relevant roughened surface.

The DFT of shop primers is determined using a special procedure, which is available from Hempel on request. For more detail on film thicknesses, see the *Film thickness* section below.

Surface preparation

A short description of the surface preparation recommended (cleanliness and roughness) to obtain proper adhesion of the product. Detailed surface preparation procedures and techniques are described in Hempel's technical guidelines, available on hempel.com.

Cleanliness: The degree of cleaning as defined by ISO 8501-1:2007: *Preparation of steel substrates before application of paints and related products*. This requires a visual assessment of surface cleanliness unless otherwise indicated.

For other substrates than steel, please refer to the technical guidelines and/or the specification. For previously painted surfaces, basic cleaning method and degree of preparatory cleaning is most often described, otherwise refer to the guidelines and/or specification.

Roughness: The roughened substrate is characterised by both surface roughness and roughness profile. These must be evaluated separately. Surface roughness is defined as the irregularities in surface texture caused by blast cleaning; roughness profile is characterised as round or sharply edged.

When a roughness profile is given in Hempel's PDS, it is normally a sharp profile. The profile specified refers to one or more of the roughness comparators: Rugotest No. 3 or the ISO Comparator.

Application

Mixing ratio
Multi-component, chemically curing products are supplied as separate components (the base product, curing agent and/or other additives) in the correct mixing ratio. The mixing ratio must be strictly adhered to (even when mixing smaller amounts) and the individual components must be thoroughly stirred before they are combined.

For multi-component products, it is very important that the prescribed amount of curing agent is added to the base. In order to ensure this is done, it is recommended that the thinner recommended in the PDS is used to flush all of the curing agent out of the can. As a general rule, the curing agent should be added to the base, not the opposite.

Once the material has been mixed, curing will begin. At this stage, the temperature of the mixed product often rises, which may affect pot life. Therefore, prepare only the quantity to be used within the pot life of the mixture.

Thinner
After stirring (or mixing for multi-component products), Hempel's paints are ready to apply at the film thickness stated in the PDS or in the specification. If the paint is too thick (e.g. in cold weather or for special purposes, such as application in a lower film thickness), the thinner(s) indicated in the PDS may be added to give the required viscosity.

Use only the recommended thinner. Using the wrong thinner may negatively affect the coating system's properties.

The amount of thinner required depends on the prevailing temperature, application method, etc. The usual maximum percentage of thinner is indicated for the respective application method (see section on *Application method* below). Unnecessary thinning should be avoided. For many products, thinning is only recommended in exceptional cases. If more thinning is deemed necessary under special circumstances, consult Hempel.

Adding a small percentage of thinner will result in no measurable difference in the film thickness. However, when a higher degree of thinning is necessary, it should be kept in mind that adding thinner increases the quantity of liquid paint without increasing the solids content. Consequently, a proportionally higher wet film thickness must be applied in order to obtain the specified DFT. The volume solids content after thinning is calculated using this formula:

$$\text{Volume solids (\%) (after thinning)} = \frac{\text{Volume solids (\%)} \times 100}{(\text{\% thinner added} + 100)}$$

Cleaner
In most circumstances, the thinner recommended for thinning the product can also be used for cleaning the application tools. However, for some products, special cleaning agents are recommended. This will be stated in the PDS.

Please note that tools used for silicone products or waterborne paints may be particularly difficult to clean. It is important to follow the cleaning instructions in the PDS or in the technical application guideline available on hempel.com.

Pot life
The time from mixing the individual components in a multi-component product to the point when the mixed paint is no longer useable.

Pot life is shown at up to three temperatures within the optimal paint temperature range for the specific product. If the paint's temperature is outside this range, the following rule of thumb may be used.

For solvent-borne paints:
- Pot life is halved for every 10°C [18°F] increase in temperature
- Pot life is doubled for every 10°C [18°F] decrease in temperature.

For waterborne paints:
- Pot life *increases* with increasing temperature.

For Hempadur products, the pot life is usually shorter for airless spray application than for brush application. This is because the anti-sagging properties of the product are gradually lost over time. Thus, high DFTs specified for airless spray application are only obtainable within a shorter pot life.

Please note that pot life cannot be extended by thinning.

Application method
The recommended methods for applying the product in order of priority. If thinning is required, the normal maximum thinning is indicated for each method. In some cases, higher thinning rates may be needed, consult the specification.

For airless spray, a typical nozzle orifice and nozzle pressure – or a range of nozzle parameters – are shown. Be aware that airless spray data are for guidance only and may require adjusting depending on equipment, working conditions and other requirements.

In general, more coats are required to achieve the specified DFT when the coating is applied by brush or roller instead of spraying.

Film thickness
Depending on the product, the dry/wet film thickness (DFT/WFT) and the corresponding theoretical spreading rate are either listed as a range or shown as a single recommended value for the *standard* shade listed in the PDS.

The wet film thickness value is calculated as follows:

$$\text{WFT (microns (or mils))} = \frac{\text{DFT (microns (or mils))} \times 100}{\text{Volume solids (\%)}}$$

and subsequently rounded to the nearest WFT gauge (comb gauge).

The low and high values show the specification range for the product, but other thicknesses could be optimal in specific situations. Please be aware that using other thicknesses will alter the spreading rate, drying/curing time and the overcoating intervals indicated in the PDS. For most products, the PDS will state the highest acceptable DFT above which the performance of the paint or the paint system might be impaired and defects such as sagging, cracking, wrinkling, etc may occur.

Any film thickness specified in a Hempel specification supersedes the values shown in the PDS.

Theoretical spreading rate
The theoretical spreading rate (TSR) of the paint at a given dry film thickness on a completely smooth surface, calculated as follows:

$$\text{Theoretical spreading rate } (\frac{\text{m2}}{\text{L}}) = \frac{\text{Volume solids (\%)} \times 10}{\text{Dry film thickness (microns)}}$$

In most cases TSR is also stated in the US unit ‘sq ft/US gal’.

Please note that an increase in film thickness decreases the corresponding spreading rate and vice versa.

Actual consumption (practical spreading rate) may be higher than the theoretical value. However, the practical spreading rate is not given in the PDS, because the variation from case to case is large and dependent on many factors. Consumption is mainly affected by: the roughness of the substrate, presence of welding seams, film thickness variances during application, complexity and size/shape of the surface (which may increase paint overlapping) and physical losses from cans, pumps, hoses, etc.

The theoretical spreading rate cannot be given for paint materials used for saturation of an absorbing substrate, such as wood, concrete, etc.

Application conditions
The recommended climatic conditions for good application. If climatic or other limitations beyond what is dictated by normal good painting practice apply, this is indicated here. As a general rule, paint should never be applied under adverse weather conditions.

Even if the weather seems fit for painting, condensation will occur if the temperature of the substrate is at or below the dew point (the temperature at which the atmospheric humidity condenses as dew or ice). To compensate for fluctuations, the surface temperature should be at least 3°C [5°F] above the dew point during both painting and drying. Beware of ice on the surface when painting at temperatures below freezing.

Preferably, keep the paint temperate above 15°C [60°F], otherwise the paint will require excessive thinning, which will increase the risk of sagging. Viscosity of the paint will increase if the temperature decreases.

In confined spaces, it may be necessary to remove solvent vapours or water vapours by ensuring there is adequate fresh air or mechanical ventilation during application and drying, both to assist evaporation and for safety and health.

Drying and overcoating

Product compatibility
Recommendations for preceding and subsequent paints that are compatible with the product. No limitation is implied. Other compatible products may be specified depending on the purpose. In this context, shop primers are regarded as an integral part of surface preparation. The specification supersedes any recommendation given in this section.

Drying time
Drying/curing time, measured according to standard methods or, in some cases, according to local Hempel procedures.

During measurement, standard conditions relevant for the product in question are applied, including temperature range, relative humidity, film thickness, etc. Changing those parameters will affect drying and curing time. Therefore, the drying/curing times indicated in the PDS may be different under operational conditions.

The drying/curing time is the time needed to reach the stages defined below:

Touch dry: The film is sufficiently solidified, by solvent evaporation, chemical reaction or both, so that it no longer flows or sticks to a finger when lightly touched. It is measured according to ISO 9117-4: *Paints and varnishes - Drying tests - Part 4: Test using a mechanical recorder*.

Surface dry: The state of a coat of paint or varnish when ballotini (small transparent glass spheres) can be applied and lightly brushed away without damaging the surface of the coating. It is measured according to ISO 9117-3 or ISO 9117-4: *Paints and varnishes - Drying tests - Part 3: Surface-drying test using ballotini* or *Part 4: Test using a mechanical recorder*.

Hard dry: When the drying or curing reaction (or both) has proceeded sufficiently so that the film is not displaced, nor is any noticeable mark left, when the panel is pinched between the thumb and forefinger (with the thumb on the coating film) with a relatively strong force. It is measured according ISO 9117-4: *Paints and varnishes - Drying tests - Part 4: Test using a mechanical recorder*.

Dry to handle: When there is no loosening, detachment, wrinkling or other evidence of distortion of the film after the following test: The tester places a thumb on the film while holding his/her arm in a vertical line from the wrist to the shoulder. He/she then pushes down onto the film, exerting maximum pressure while turning his/her thumb through a 90° angle along the plane of the film. Dry-to-handle is measured according to ASTM D1640: *Standard test methods for drying, curing, or film formation of organic coatings at room temperature*.

Through dry: The coating film is dry throughout its thickness; or it has solidified so completely that a large twisting force can be applied without distorting the film. It is measured according to ISO 9117-1 or ISO 9117-4: *Paints and varnishes - Drying tests - Part 1: Determination of through-dry state and through-dry* or *Part 4: Test using a mechanical recorder*.

Dry to walk on: The paint surface is sufficiently hardened to be walked on by a person without being damaged. It is measured using an internal Hempel test method.

Fully cured: The paint film has achieved maximum hardness, as determined by an internal Hempel evaluation.

Overcoating with itself: A film is considered dry for overcoating with itself when a second coat can be applied without the development of any film irregularities, such as lifting or loss of adhesion of the first coat, and the drying time of the second coat does not exceed the maximum specified (if any) for the first coat (ASTM D1640). It is measured by an internal Hempel test method based on a number of ISO and ASTM standard methods.

The overcoating intervals stated in the drying table are intended as a guideline only, as a number of conditions affect overcoating intervals, including temperature, film thickness, number of coats, atmospheric conditions before overcoating, etc. Unless otherwise stated, spray application is assumed – other application procedures, such as brush application, may require longer intervals.

The overcoating times shown are for the future corrosive environment that is most relevant for the paint/paint system (i.e. atmospheric conditions of mild, medium or severe as defined in ISO 12944; corrosion classes C3 and C4, etc.) Where relevant, overcoating intervals are given for immersion service in water.

Minimum and maximum intervals
The period of time after the application of a base coat when a second coat can be successfully applied without experiencing defects in the coating system during its service life.

Unless otherwise stated in the specification, minimum and maximum intervals should always be adhered to if the paint system is to provide maximum protection. The specification always supersedes any guideline overcoat intervals given in the PDS.

The minimum interval is prolonged by a factor of approximately 1.7 if the film thickness is on average 50% higher than specified and a factor of approximately 2.4 for an average film thickness 100% higher.

The effects of overcoating before the stated minimum time could be wrinkling, bleeding through of the base coat, and solvent entrapment and retention, which may cause loss of adhesion or other defects during the coating system's service life.

The effect of exceeding the recommended overcoating interval is typically reduced adhesion between the two coats. This may result in detachment or peeling, which could be further worsened by exposure to humidity, abrasion, temperature fluctuations and/or further overcoating.

For some paint types, the overcoating interval may not be critical for adhesion. In this case, the maximum overcoating interval is denoted as 'none'. Regardless, a primer coat should not be left unprotected for a very long time in an aggressive environment.

When the overcoating interval is denoted as 'extended', it may be possible to extend the time before overcoating, depending on the condition and cleanliness of the paint's surface as well as exposure conditions, such as exposure to sunlight. Evaluation of the specific situation must be based on local experience. For advice, contact Hempel.

Drying conditions
The drying time stated in the table requires the continuous removal of solvent vapours from above the paint film. When painting indoors, it is essential to have sufficient ventilation during application, drying and curing (please also see notes in the *Application conditions* section above).

Overcoating details
Any special recommendations related to overcoating.

Before overcoating, the surface must always be thoroughly cleaned of any oil, grease, salt, dust or other contaminant. Exposure to sunlight has a marked effect on the maximum overcoating interval for some products and should also be taken into consideration.

If the maximum overcoating interval is exceeded, it may be necessary to roughen the surface to ensure adhesion to the next coat. After exposure in a polluted environment, thorough cleaning by high-pressure freshwater hosing or another appropriate method is always recommended before overcoating.

Note: For epoxy and polyurethane paints, moisture and carbon dioxide may result in a greasy surface, preventing adhesion to the subsequent coat. In particular, this tends to occur at low temperatures and high humidity.

Other remarks
Any other relevant data or information.

Storage

Shelf life
The time from the date of production to the point at which the quality of the paint can no longer be assured, assuming the paint has been stored correctly, in original unopened containers. The can will include a 'best before' label for guidance. Thereafter, the product quality must be re-inspected. For advice, please consult Hempel.

Storage conditions
In general, paints and paint components should not be stored at temperatures above 40°C [104°F]. For some products, the storage temperature must be lower (this will be clearly stated on the label). Waterborne paints must not be exposed to frost.

Long-term storage and storage at high temperatures may require careful remixing of the paint prior to application due to (slight) sediment in the can. If the product has been stored at temperatures above 40°C [104°F] or the storage conditions in general are unknown, consult Hempel for advice on suitability.

Additional documents

A list of relevant technical documents. The documents are available on hempel.com or on the relevant local Hempel website.

General note

All decimals of Hempel's source data are used when calculating derived parameters such as theoretical spreading rate, wet film thickness, conversion between SI and US units, etc.

On the other hand, figures shown in the PDS are rounded-off to the number of significant digits most appropriate for the parameter in question. This entails that if directly converting figures shown in the PDS to derived parameters, rounding errors will appear.