Explanatory notes to Product Data Sheets (PDS)

The Product Data Sheets (PDS), comprise descriptions of the products, product data, and guidelines/recommendations for their use. The purpose is to achieve the best possible results when using the products.

Shade numbers
Hempel paints are supplied in colours identified by a 5-character, standard shade code as follows:

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 directly correlate to official colour standard codes. Colours corresponding to specific official standard colours may be established.

Frequently used colours/shades are displayed in Hempel's colour cards.

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

Note: Shade variation may be expected for products where deviations are of less importance such as primers, many intermediates and antifoulings. Uniform appearance of a topcoat is best obtained by applying paint with same batch number.

Quality numbers
Product number + shade number.

Description
A short description of the product with emphasis on generic type, pigmentation, principal properties, and certain limitations.

Recommended use
The purpose(s), for which the product is designed or particularly well suited. The product may be specified for other uses in tailor-made paint systems for specific purposes.

Features
Summary of the most important product features.

Service temperature
Indicates the maximum temperature that will have no immediate detrimental effect on the paint.

A service temperature constantly near the maximum will result in a shorter lifetime of the specified paint system compared to the lifetime anticipated when operating at ambient temperatures. If service temperatures often fluctuate between ambient temperatures and near maximum temperatures, this will result in an additional decrease in the anticipated lifetime of the paint system 'accelerated ageing'.

Most paints will change appearance when exposed to high temperatures, either by a change in colour and/or by loss of gloss.

In addition many paints will become soft at high temperatures and show higher sensitivity to mechanical or chemical actions.

Exposure to warm liquids, water included, will normally only be recommended for dedicated paint systems. At high temperatures, wet service will have a more pronounced influence on lifetime compared to dry service.

When a paint system is exposed to fluctuations of temperatures, wet service conditions will induce more stress to the coating system than dry service at the same temperatures.

It is of importance whether the liquid has a higher temperature than the coated steel. A 'cold wall' effect will increase the risk of blistering and put further limitations to the temperature resistance. Most paint systems only tolerate a very low negative gradient of temperature under wet/immersed service conditions.

Approvals, certificates
A list of key certificates and approvals. Other certificates and approvals than listed may be available from Hempel upon request.

Availability
Delivery of certain products requires notice in advance for logistics reasons. Some product may not be available in specific countries e.g. due to local legislation. This is indicated by the expression 'Local availability subject to confirmation'.

Physical constants

Colours/shade nos
See shade numbers on page 1. Certain physical constants may vary from one colour to another.

Finish
The appearance of the paint film after drying under optimum conditions in laboratory, given as high gloss (>90), glossy (60-90), semi-gloss (30-60), semi-flat (15-30), or flat (<15). All figures are in gloss units and according to ISO 2813:1994(E), (specular gloss, 60° geometry). The actual appearance will depend on the conditions during application and drying/curing.

Volume solids
The Volume Solids (VS), figure expresses in percentage the ratio:

$$\frac{\text{Dry film thickness}}{\text{Wet film thickness}}$$

The stated figure is determined under laboratory conditions, after a drying period of 7 days at 23°C/73°F and 50 percent relative humidity according to ISO 3233:1998, drying class 2.

For 100 percent solids volume products the theoretical value is indicated. This value is not reflected in the ratio:

$$\frac{\text{Dry film thickness}}{\text{Wet film thickness}}$$

For all 100 percent products due to shrinkage during curing.

All volume solids values are given with ±1 - ±3 percent, which is the standard deviation taking into account normal manufacturing tolerances, experimental uncertainty etc.

Theoretical spreading rate
The theoretical spreading rate of the paint in a given dry film thickness on a completely smooth surface is calculated as follows:

$$\frac{\text{Volume solids x 10}}{\text{Dry film thickness (micron)}} \quad \text{m}^2\text{/litre}$$

$$\frac{\text{Volume solids \% x 16.04}}{\text{Dry film thickness (mils)}} \quad \text{sq.ft./US gallon}$$

1 mil is rounded off to 25 micron - the exact value is 25.4 micron.

In the PDS the theoretical spreading rate is stated for the indicated dry film thickness (DFT), that is usually specified for the product. Some products may be specified in different dry film thicknesses for different purposes, which affects the spreading rate accordingly. Theoretical spreading rate cannot be given for paint materials used for saturation of an absorbing substrate, wood, concrete, etc.

The correction factors due to roughness of ISO 19840 have not been taken into account in the PDS. Actual consumption will be higher when applying as a primer on substrate with roughness.

The practical spreading rate is not given in the PDS as the variation is too great to be represented by one single figure.

Consumption factor
The practical consumption is estimated by multiplying the theoretical consumption with a relevant consumption factor (CF).

The consumption factor depends on a number of external conditions and cannot be stated in the PDS as the variation is too great to be represented by one single figure.

$$\text{Practical consumption} = \frac{\text{Area x CF}}{\text{Theoretical spreading rate}}$$

The variation in the consumption factor is largely attributed to the following:

1) **Waviness of paint film**
A manually applied paint film will unavoidably:
a) show some waviness of the surface and,
b) a thickness distribution with an average value somewhat higher than the specified dry film thickness in order to fulfil e.g. an 80:20 rule. This leads to higher consumption than theoretically calculated.

2) **Complexity and size/shape of the surface to be calculated**
Complex, odd-shaped and small-sized surfaces are virtually impossible to paint without overspray and will therefore lead to higher consumption than theoretically calculated from the area in question.

3) **Surface roughness of the substrate**
Surface roughness of the substrate gives a 'dead volume' to be filled up or in the case of shopprimers a 'surface area ratio' greater than one and will therefore cause a higher consumption than theoretically calculated for a smooth substrate.

4) **Physical losses**
Factors such as residues in cans, pumps and hoses, discarded paint due to exceeded pot life, wind loss, etc. will all contribute to a higher consumption.

The practical spreading rate thus varies with method of application, skill of the painter, shape of the object to be painted, texture of the substrate, film thickness applied, and working conditions.

In any case it is not beneficial to stretch the paint as much as possible, but rather try to obtain the specified thickness of the applied paint on the entire area.

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.

The flash points of Hempel's paints are measured according to the Setaflash method (closed cup). For two-component products flash points are normally given for the mixed products. The figures are given as guidance with a view to local regulations for precautions against fire during use.

Adding thinner to a paint may change the flash point of the diluted material.

Specific gravity
The weight in kilograms per litre at 25°C/77°F.
An equivalent figure is given in lbs per US gallon.

For two-component products the specific gravity is given for the mixed product.

The specific gravity may in practice vary in an interval of a few percent compared to the theoretical value indicated in the PDS.

Drying time in the Product Data Sheet
Surface-dry refers to surface-drying time, which is defined and measured as described in the international standard ISO 9117-3.

Through-dry refers to through-dry time, which is defined and measured as described in the international standard ISO 9117-1.

Dry to touch refers to the time the paint reaches stage III on a Beck Koller recorder (ASTM D 5895-03).

Fully cured
The curing time is given for two-component products at a (steel) temperature of 20°C/68°F and adequate ventilation.

V.O.C.
The calculated weight of volatile organic content in grammes per litre. An equivalent figure is given in lbs per US gallon. Detailed information on VOC of specific products is given in the product's Safety Data Sheet.

Shelf life
The time the product will keep in good condition when stored under cover in original, sealed containers under normal storage conditions. Shelf life is indicated in the PDS only if it is one year or less at 25°C/77°F. It will decrease at higher temperatures, e.g. will be almost halved at 35°C/95°F. The canned product will carry a 'best before' label for guidance.

If no specific limitation is given, a paint should not be stored for more than five years at 25°C/77°F or three years at 35°C/95°F for one-component products and three years at 25°C/77°F or two years at 35°C/95°F for two-component products from the date of production.

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 storage conditions are unknown and in any other cases of doubt about the suitability of a paint material, this can easily be verified by checking the following:

a) no corrosion of the inside of undamaged cans, when opened
b) apparent viscosity in can: after remix, paint must not appear gelatinous or require excessive thinning prior to proper application
c) application in specified film thickness: a uniform, closed paint film must be shown
d) drying time to be within the limit specified in the PDS

Batch number
All products carry a 9-digit batch number indicating manufacturing unit and the date of production:

The first two digits indicate the production site. This information is required for products carrying certain certificates and type approvals, e.g. products approved according to IMO Resolution MSC 215(82).

The third digit indicates the year of production, while the fourth and fifth digits indicate the month of production.

Storage temperature
In order to maintain application properties as designed, paints should not be stored at temperatures above 50°C/122°F prior to application. Waterborne paints must not be exposed to frost.

Application details

Mixing ratio
Two-component, chemically curing products are supplied as base and curing agent in the correct mixing ratio. The mixing ratio must be strictly adhered to, also when subdividing; as a general rule, add the curing agent to the base.

It is very important for two-component products that the prescribed amount of curing agent is added to the base. In order to ensure this is done, it is in most cases recommended to use the indicated thinner to flush the curing agent can. Once the material has been mixed the curing will proceed. Therefore, only the quantity needed within the pot life of the mixture should be mixed at a time.

Application method
Gives the possible or recommended method(s) of application. As a general rule, the first coat of a rust-preventing primer should be applied by brush or airless spray to obtain the best possible wetting and penetration into the substrate.

Application by brush or roller usually requires more coats to be applied to achieve the specified film thickness than application by airless spray equipment.

Thinner (max.vol)
Hempel's paints are delivered ready for application at 20°C/68°F by brush or airless spray after stirring (for two-component products after mixing of base and curing agent), in a given normal dry film thickness. If the paint is too thick, e.g. in cold weather or for special purposes such as application in lower film thickness, the thinner(s), indicated under this heading may be added to give the required viscosity. The amount of thinner to be added depends on prevailing temperature, application method, etc. The usual maximum percentage is indicated for the respective application method. If more thinning is deemed necessary under special circumstances, consult Hempel.

Adding a small percentage of thinner will give no measurable difference in the film thickness. There are cases, however, when a higher degree of thinning is necessary and justified. It should then be kept in mind that adding thinner increases the quantity of liquid paint without contributing to the solids content. Consequently, a proportionally higher wet film thickness must be applied when adding any significant amount of thinner in order to obtain the specified dry film thickness.

$$\text{VS\% after thinning} = \frac{\text{VS\%} \times 100}{\text{\% thinner added} + 100}$$

Example

If 0.5 litres of thinner is added to 20 litres of paint, then the percentage of thinner added equals

$$\frac{0.5 \times 100}{20} = 2.5\%$$

VS percentage after thinning equals

$$\frac{\text{VS\%} \times 100}{102.5}$$

Avoid unnecessary and habitual thinning.

Use only the recommended thinner(s). Using wrong thinner may negatively affect the properties of the applied coating system.

Pot life
Roughly speaking, the pot life for solvent-borne paints depends on the paint temperature as follows:

The pot life is halved at an increase in temperature of 10°C/18°F, and doubled at a decrease in temperature of 10°C/18°F.

For Hempadur products the pot life is usually shorter for application by airless spray than for brush application. This is due to the fact that the anti-sagging properties are gradually lost after expiration of the pot life indicated for airless application. Thus the high dry film thickness usually specified for airless spray application is only obtainable within the pot life indicated for airless application.

Note: Pot life cannot be extended by thinning.

In the case of waterborne, two-component epoxy products this rule of thumb does not apply. The influence of temperature on the pot life is noted in the relevant data sheets.

Nozzle orifice
A typical nozzle orifice (or a range of nozzle orifices), is indicated.

Nozzle pressure
A nozzle pressure generally suitable is given.

Note: Airless spray data is offered as guidance and are subject to adjustment to suit the work at hand.

Cleaning of tools
Normally the thinner indicated for the product can be used for cleaning of tools after use. Where special cleaning agents are recommended, it is indicated on the PDS.

Tools used in connection with waterborne paints may be difficult to clean. Therefore, it is especially important to follow the instructions stated in the PDS.

Indicated film thickness, dry
Dry film thickness (dft), is indicated in a thickness frequently used in specifications.

Note: Several products are specified in different film thicknesses for different purposes.

Dry film thicknesses are generally checked with gauges calibrated on smooth reference steel panels. Shopprimers are controlled according to a special procedure available from Hempel upon request.

Indicated film thickness, wet
Wet film thickness (wft), is indicated in multiples of 25 microns (1 mil), in order to facilitate the practical measurements with the wet film thickness gauge (comb gauge). These values are rounded off to the multiple of 25 which is regarded most relevant in each case.

Overcoating interval
The minimum and maximum overcoating intervals refer to overcoating with the product itself as well as with other relevant products such as topcoats. Minimum and any maximum intervals should always be adhered to if the paint system is to provide maximum protection.

Data is given for the relevant temperature range for the product application at the indicated film thickness. The intervals also refer to future exposure in atmospheric conditions corresponding to corrosion classes C3 and C4 according to ISO 12944-2 and with limited mechanical wear. Where relevant, overcoating intervals are also given for immersion service in water.

Overcoating intervals are intended as guidelines as, apart from temperature, film thickness and future service conditions, they are also related to film number of coats, type of exposure before overcoating and will be affected correspondingly.

Details about overcoating intervals for complete coating systems are stated in the relevant painting specification, available upon request. A specification supercedes any guideline overcoat intervals indicated in the PDS or application instructions.

Minimum interval
The quoted figures for the minimum interval assume that the coating has been applied according to the PDS in the recommended film thickness, with good ventilation during drying and within the recommended temperature range. Spray application is assumed – other application procedures such as brush application may require longer intervals.

Beware of the undesired influence of moisture and carbon dioxide on epoxy and polyurethane paints which especially occurs at low temperatures and high humidity. This will result in a greasy surface preventing any adhesion of the subsequent coat.

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

Maximum interval
For maximum intervals the temperature in this context is the highest surface temperature during the period.

Before overcoating, the surface must always be thoroughly cleaned from any oil, grease, salt, dust or other contamination.

For some paint types the interval may not be critical in respect of adhesion, but a primer coat should not be left unprotected for too long in an aggressive environment. The maximum overcoating interval for such products is denoted ‘none’.

Exposure to sun has a marked effect on the maximum overcoating interval for some products and this must be taken into consideration. If the maximum interval is exceeded, it may be necessary to roughen the surface to ensure adhesion of the next coat. When the interval is denoted ‘extended’ the coated structure can possibly be overcoated even after longer periods, depending on the actual exposure conditions, such as limited exposure to sun and depending on the condition and cleanliness of the paint surface. The evaluation of the specific situation must be based on local experience, contact Hempel for advice.

After exposure of any painted surface in polluted environment thorough cleaning by high pressure fresh water hosing or another appropriate measure is always recommended before overcoating.

Safety
Under this heading general safety precautions when handling or working with the product are given. Packings are provided with applicable safety labels which should be observed. In addition, safety data sheets, national or local safety regulations should always be followed.

Surface preparation
The recommended degree of cleaning of the surface before painting. The degrees of cleaning refer to ISO 8501-1:2007. Preparation of steel substrates before application of paints and related products – visual assessment of surface cleanliness, unless otherwise indicated.

For some products a minimum surface profile is mandatory. The profile specified is given with reference to one or more of the roughness comparators: Rugotest No. 3, Keane-Tator Comparator, or the ISO Comparator.

For previously painted surfaces the method and degree of preparatory cleaning is generally indicated.

Application conditions

If climatic or other limitations beyond what is dictated by normal good painting practice apply to the use of a particular quality of paint, this is indicated under this heading. As a general rule, paint should never be applied under adverse weather conditions. Even if the weather seems fit for painting, there will be condensation if the temperature of the substrate is at or below the dew point (the temperature at which the atmospheric humidity condenses, e.g. as dew). To compensate for fluctuations the temperature of the surface should be at least a few degrees above the dew point during painting and drying. 3°C/5°F is often quoted as safe.

Beware of ice on the surface at temperatures below the freezing point.

In confined spaces it may be necessary to remove solvent vapours or water vapours by providing an adequate amount of fresh air constantly during application and drying, both for reasons of safety and health, and to assist evaporation.

Keep the paint temperate, preferably above approximately 15°C/59°F when applying during winter. If not, the paint will require excessive thinning leading to an increased risk of sagging. Viscosity in any paint will increase if the temperature decreases.

Preceding coat
Recommendations of some preceding paint(s), known to be compatible with the product. No limitation is implied. Other compatible products may be specified depending on the purpose. In this context, shopprimers are regarded as an integral part of the surface preparation.

Subsequent coat
Recommendations of some subsequent paint(s), known to be compatible with the product. No limitation is implied. Other compatible products may be specified depending on the purpose.

Remarks

Under this heading other relevant data or information is included.

Issued by
The Hempel R&D region that developed the product. This field demonstrates which R&D region owns the product.

Example

Denmark/Group: Hempel A/S – product reference
Spain: Hempel Pinturas S.A.U

Note: The PDS are subject to change without notice and automatically become void five years from issue. The date of issue is depicted in the footer of each page.

Additional notes and definitions of expressions used

Surface cleaning*

Description	
Low pressure water cleaning (LP WC)	Up to 340 bar/ 5000 psi
High pressure water cleaning (HP WC)	340-680 bar/ 5000-10.000 psi
High pressure water jetting (HP WJ)	680-1700 bar/ 10.000-25.000 psi
Ultrahigh pressure water jetting (UHP WJ)	Above 1700 bar/ 25.000 psi

*As defined in 'joint surface preparation standard NACE no. 5/SSPC-SP 12, 1995'.

Note: Wet abrasive blasting may be performed with low or high pressure fresh water to which a relatively small amount of abrasives is introduced. In some cases inhibitors are added to prevent flash rusting (however, as a general rule it is recommended not to use inhibitors when cleaning areas to be immersed during service. Surplus of inhibitors may lead to osmotic blistering).

Damp surfaces
Water is not readily detectable, but the temperature of the surface is below the dew point.

Moist surfaces
Pools of water and droplets have been removed, but there is a noticeable film of water.

Wet surface
Droplets or pools of water are present.

Blast primer
A paint used for short term protection of a newly blast-cleaned steel surface of an assembled structure in order to ease the working procedures. In this context blast primers are often regarded an integral part of the surface preparation.

Holding primer
A paint used to prolong (hold), the protective lifetime of a shopprimer until the specified paint system can be applied, but is now used synonymously as a blast primer.

Mist coat/flash coat
A thin coat (10-25 µm), achieved by applying a thinned paint by swift spray passes/with heavy atomisation. In common usage, the terms are used synonymously.

Mist/flash coats are extensively used to saturate the porosities in zinc silicates and thermally sprayed metals with solvents prior to application of a full paint film. But also sealer coats and tie coats are often applied as mist coats/ flash coats.

Tiecoat
A layer of paint which improves the adhesion between coatings of different generic types, e.g. to 'bridge' between conventional and advanced coatings, or between epoxy and physically drying paints.

Sealer coat
A layer of paint which is used to seal off (fill the pores of), porous surfaces such as concrete, zinc silicates and empty, insoluble matrix of certain antifoulings. In this connection it prevents disturbance of the balance between binder and active pigments of the new antifouling. Furthermore, certain paints may be used as sealer coats
to minimise popping of the following coat(s), when painting a porous substrate.

Spillages and splashes
When a product is mentioned to be resistant to spillages and splashes of certain chemicals, this is understood to be limited in both area and time. The spilt chemical must be removed as soon as possible and not later than 1-2 days. Cosmetic change may appear.

Metric and US units
When converting between metric and US units figures may be rounded to an appropriate number of digits.

Surface preparation standards

A number of official and unofficial standards for cleaning of steel preparatory to painting are used.

Other prominent standards, notably:

Steel Structures Painting Council (U.S.A.): Surface preparation specifications (SSPC-SP 2, 3, 5, 6, 7, 10 and 12)

and

International Standardisation Organization ISO 12944, parts 1 through 8: Corrosion protection of steel structures by protective paint systems,

also concern with the equipment, materials and procedures used to achieve the specified finish.

The British Standards; BS 4232 and BS 7079 are both superseded by ISO 8501-1.

The American standard uses the same photos as ISO 8501-1. ISO 12944 refers to ISO 8501-1, but includes also descriptions for secondary surface preparation with reference to ISO 8501-2.

They all take into account the state of the raw steel surface before cleaning and grade the result accordingly:

a: steel surface largely covered with adherent mill scale but little, if any, rust
b: steel surface which has begun to rust and from which the mill scale has begun to flake
c: steel surface on which the mill scale has rusted away or from which it can be scraped, but with slight pitting visible under normal vision
d: steel surface on which the mill scale has rusted away and on which general pitting is visible under normal vision

A surface preparation method using high pressure water for cleaning is getting more common. The best definition of terms and surface preparation standards is presented by ISO 8501-4.

For comparison of the standards see the following pages. The text of the individual standards are quoted literally.

ISO 8501-1:2007

Designation	Description
Sa 3	**Blast-cleaning to visually clean steel** When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and shall be free from mill scale, rust, paint coatings and foreign matter. It shall have a uniform metallic colour.
Sa 2.5	**Very thorough blast-cleaning** When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from mill scale, rust, paint coatings and foreign matter. Any remaining traces of contamination shall show only as slight stains in the form of spots or stripes.
Sa 2	**Thorough blast-cleaning** When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from most of the mill scale, rust, paint coatings and foreign matter. Any residual contamination shall be firmly adhering (see note 2 below).
Sa 1	**Light blast-cleaning** When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from poorly adhering mill scale, rust, paint coatings and foreign matter (see note 2).

Notes:
1. The term ‘foreign matter’ may include water-soluble salts and welding residues. These contaminants cannot always be completely removed from the surface by dry blast-cleaning, hand and power tool cleaning or flame cleaning; wet blast-cleaning or hydrojetting may be necessary.
2. Mill scale, rust or a paint coating is considered to be poorly adhering if it can be removed by lifting with a blunt putty knife.

Designation	Description
St 3	**Very thorough hand and power tool cleaning** As for St 2, but the surface shall be treated much more thoroughly to give a metallic sheen arising from the metallic substrate.
St 2	**Thorough hand and power tool cleaning** When viewed without magnification, the surfaces shall be free from visible oil, grease and dirt, and from poorly adhering mill scale, rust, paint coatings and foreign matter (see note 2).

Notes:
1. For descriptions of surface preparation methods by hand and power tool cleaning, including treatment prior to, and after, the hand and power tool cleaning procedure, see ISO 8504-3.
2. Preparation grade St 1 is not included as it would correspond to a surface unsuitable for painting.

SSPC

Designation	Description
SSPC-SP-5	1.1 A white metal blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter. 1.2 Acceptable variations in appearance that do not affect surface cleanliness as defined in section 1.1 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasive, and differences in the blast pattern. 1.3 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system. 1.4 Immediately prior to paint application the surface shall comply with the degree of cleaning as specified herein. 1.5 SSPC-VIS 1-89 or other visual standards of surface preparation may be specified to supplement the written definition.
SSPC-SP-10	2.1 A near-white blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except for staining as noted in section 2.2. 2.2 Staining shall be limited to no more than 5 per cent of each square inch of surface area and may consist of light shadows, slight streaks, or minor discolourations caused by stains of rust, stains of mill scale, or stains of previously applied paint. 2.3 Acceptable variations in appearance that do not affect surface cleanliness as defined in sections 2.1 And 2.2 Include variations caused by type of steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasives, and differences in the blast pattern. 2.4 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system. 2.5 Immediately prior to paint application, the surface shall comply with the degree of cleaning as specified herein. 2.6 SSPC-VIS 1-89 or other visual standards of surface preparation may be specified to supplement the written definition.
SSPC-SP-6	3.1 A commercial blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except for staining, as noted in section 3.2. 3.2 Staining shall be limited to no more than 33 per cent of each square inch of surface area and may consist of light shadows, slight streaks, or minor discolouration caused by stains of rust, stains of mill scale, or stains of previously applied paint. Slight residues of rust and paint may also be left in the bottoms of pits if the original surface is pitted. 3.3 Acceptable variations in appearance that do not affect surface cleanliness as defined in sections 3.1 And 3.2 Include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasive, and differences in the blast pattern. 3.4 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system. 3.5 Immediately prior to paint application, the surface shall comply with the degree of cleaning as specified herein. 3.6 SSPC-VIS 1-89 or other visual standards of surface preparation may be specified to supplement the written definition.

Designation	Description
SSPC-SP-7	4.1 A brush-off blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust, and loose paint. Tightly adherent mill scale, rust and paint may remain on the surface. Mill scale, rust and paint are considered tightly adherent if they cannot be removed by lifting with a dull putty knife. 4.2 The entire surface shall be subjected to the abrasive blast. The remaining mill scale, rust or paint shall be tight. 4.3 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system. 4.4 Immediately prior to paint application, the surface shall comply with the degree of cleaning as specified herein. 4.5 SSPC-VIS 1-89 or other visual standards of surface preparation may be specified to supplement the written definition.
SSPC-SP-2	5.1 Hand tool cleaning is a method of preparing steel surfaces by the use of non-power hand tools. 5.2 Hand tool cleaning removes all loose mill scale, loose rust, loose paint and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust and paint be removed by this process. Mill scale, rust and paint are considered adherent if they cannot be removed by lifting with a dull putty knife. 5.3 SSPC-VIS 1-89 or other visual standards of surface preparation agreed upon by the contracting parties may be used to further define the surface.

ISO 12944-4 is not quoted but is fully in line with ISO 8501-1

Comparing the standards, there is no doubt that Sa 3 and SSPC-SP-5 are identical in their demands to surface cleanliness. Also Sa 2.5 and SSPC-SP-10 seem identical.

Concerning Sa 2 and SSPC-SP-6 these differ slightly, SSPC-SP-6 expressing higher demands to quality. SSPC-SP-6 requires remnants being stains only. Sa 2 states ‘residual contamination shall be firmly adhering’.

Note: For SSPC the written specification takes preference - for ISO 8501-1.

ISO 8501-4

Designation	Description
ISO 8501-4	Surface preparation and cleaning of steel and other hard materials by high and ultra high pressure water jetting prior to paint application. Water jetting is a relatively new method of surface preparation. The standard deals with the removal of visible and invisible contamination. After cleaning the surface will still be wet and flash rusting may occur on cleaned steel during the drying period. Maintenance being the main area of use, any old coating remaining after water jetting must be well adhering, intact and roughened by the treatment as well as compatible with the new coating system to be applied. As a general rule, coatings which are later to be exposed to severe mechanical and/or chemical exposures, like e.g. special wear and impact resistant coatings and chemically resistant tank coatings, should not be applied to water jetted surfaces. Neither should coatings for which protection relies upon metallic contact to the steel substrate, such as zinc rich primers, be applied to water jetted surfaces.

Description of the surface appearances after cleaning

Designation	Description
Wa 1	**Light high-pressure water jetting** When viewed without magnification, the surface shall be free from visible oil and grease, loose or defective paint, loose rust and other foreign matter. Any residual contamination shall be randomly dispersed and firmly adherent.
Wa 2	**Thorough high-pressure water jetting** When viewed without magnification, the surface shall be free from visible oil, grease and dirt and most of the rust, previous paint coatings and other foreign matter. Any residual contamination shall be randomly dispersed and can consist of firmly adherent coatings, firmly adherent foreign matter and stains of previously existent rust.
Wa 2½	**Very thorough high-pressure water jetting** When viewed without magnification, the surface shall be free from all visible rust, oil, grease, dirt, previous paint coatings and, except for slight traces, all other foreign matter. Discolouration of the surface can be present where the original coating was not intact. The grey or brown/black discolouration observed on pitted and corroded steel cannot be removed by further water jetting.

Description of the surface appearance for three flash rust grades

Designation	Description
L	**Light flash rust** A surface which, when viewed without magnification, exhibits small quantities of a yellow/brown rust layer through which the steel substrate can be seen. The rust (seen as a discolouration), can be evenly distributed or present in patches, but it will be tightly adherent and not easily removed by gentle wiping with a cloth.
M	**Medium flash rust** A surface which, when viewed without magnification, exhibits a layer of yellow/brown rust that obscures the original steel surface. The rust can be evenly distributed or present in patches, but it will be reasonably well adherent and it will lightly mark a cloth that is gently wiped over the surface.
H	**Heavy flash rust** A surface which, when viewed without magnification, exhibits a layer of red-yellow/brown rust that obscures the original steel surface and is loosely adherent. The rust layer can be evenly distributed or present in patches and it will readily mark a cloth that is gently wiped over the surface.

For further details, please refer to ISO 8501-4

Designation	Description
SSPC-SP 12	This standard describes the use of water jetting to achieve a defined degree of cleaning of surfaces prior to the application of a protective coating or lining system. These requirements include the end condition of the surface plus materials and procedures necessary to verify the end condition. This standard is limited in scope to the use of water.

The specifier shall use one of the visual surface preparation definitions (WJ-1 to WJ-4, see below) and, when deemed necessary, one of the flash rust definitions.

Description of the surface appearances after cleaning

Designation	Description
WJ-1	**Clean to bare substrate** A WJ-1 surface shall be cleaned to a finish which, when viewed without magnification, is free of all visible rust, dirt, previous coatings, mill scale and foreign matter. Discolouration of the surface may be present.
WJ-2	**Very thorough or substantial cleaning** A WJ-2 surface shall be cleaned to a matte (dull, mottled), finish which, when viewed without magnification, is free of all visible oil, grease, dirt and rust except for randomly dispersed stains of rust, tightly adherent thin coatings, and other tightly adherent foreign matter. The staining or tightly adherent matter is limited to a maximum of 5 percent of the surface.
WJ-3	**Thorough cleaning** A WJ-3 surface shall be cleaned to a matte (dull, mottled), finish which, when viewed without magnification, is free of all visible oil, grease, dirt, and rust expect for randomly dispersed stains of rust, tightly adherent thin coatings, and other tightly adherent foreign matter. The staining or tightly adherent matter is limited to a maximum of 33 percent of the surface.
WJ-4	**Light cleaning** A WJ-4 surface shall be cleaned to a finish which, when viewed without magnification, is free of all visible oil, grease, dirt, loose rust, and loose coatings. Any residue material should be tightly adherent.

Description of the surface appearance for four flash rust grades

Designation	Description
No flash rust	A steel surface which, when viewed without magnification, exhibits no visible flash rust. Light (L), a surface which, when viewed without magnification, exhibits a layer of yellow-brown rust layer through which the steel substrate may be observed. The rust or discolouration may be evenly distributed or present in patches, but it is tightly adherent and not easily removed by lightly wiping with a cloth.
Moderate (M)	A surface which, when viewed without magnification, exhibits a layer of yellow-brown rust that obscures the original steel surface. The rust may be evenly distributed or present in patches, but it is reasonably well adherent and leaves light marks on a cloth that is lightly wiped over the surface.
Heavy (H)	A surface which, when viewed without magnification, exhibits a layer of heavy yellow-brown rust that hides the initial surface condition completely. The rust may be evenly distributed or present in patches, but the rust is loosely adherent, easily comes off, and leaves significant marks on a cloth that is lightly wiped over the surface.

For further details, please refer to SSPC-SP12.

Abrasive blasting surface profile

Not only inorganic zinc coatings and solvent-free coatings, but most paint systems require a roughened substrate surface to obtain proper adhesion. The surface profile of the roughened substrates is characterised by a surface roughness and a roughness profile, which must be itemised separately in specifications for surface preparation.

During field work the anchor pattern is conveniently assessed by visual or tactile comparison, using standardised comparators. Such comparators are e.g. Rugotest No. 3, Keane-Tator Surface Profile Comparator, and ISO 8503 surface profile reference comparators.

Surface roughness
In connection with surface preparation, roughness is defined as the irregularities in surface texture, which are caused by blast-cleaning.

The roughness can be characterised by several roughness values. Most often the roughness is designated by the maximum height of the profile (peak-to-valley height), RZz. Sometimes the arithmetical mean deviation of the profile RA, previously known as CLA- and AA-values (Centre Line Average and Arithmetical Average, respectively), is used. Designations in boldface are according to ISO standard.

Because these values may have very different numerical values assigned to them for a given surface, it is very important to distinguish between them.

It is also important to note that roughness comparison specimens may use different roughness values. Rugotest No. 3 uses roughness numbers according to ISO 1302 and 2632-2/II (now obsolete), which are assigned to RAa values. Keane-Tator Surface Profile Comparator uses the maximum average peak-to-valley height, which resembles RZz, while ISO surface profile reference comparators uses the designations ‘fine’, ‘medium’, and ‘coarse’.

Although it is not possible to calculate RAa values from RZz and vice versa, a working group of the international Standards Sub Committee TC 35/SC 12 has established that a good approximation for RZz is RAa x 6.

Roughness profile
Roughness profiles can be characterised as round or sharp edged. Steel shot produces a round profile, while not worn down steel grit as well as most mineral abrasives give a sharp edge.

When a roughness profile is given in Hempel’s PDS it is normally a sharp profile.

Because optical effects play a role when judging a surface by means of comparators, both Rugotest No. 3, Keane-Tator Surface Profile Comparator, and ISO surface profile reference comparators all have different scales for different profiles.

Rugotest No. 3 has specimens for round and sharp profiles collected in one comparator. For greater roughness values there is even a division in fine and coarse grained finish.

Keane-Tator Surface Profile Comparator has three different discs, designed by S (sand), G/S (steel or metallic grit), and SH (shot), respectively.

ISO comparators are obtainable either as a ‘G’ version or a ‘S’ version for use on gritblasted and shotblasted surfaces, respectively.

The disc corresponding to the abrasive used must be selected for comparison.

Conversion tables

To convert	From	To	Multiply by
Distance	mil	micron	25.4
	micron	mil	0.039
	inches	centimetre (cm)	2.54
	centimetre (cm)	inches	0.3937
	feet	metre	0.3048
	metre	feet	3.2808
	yards	metre	0.9144
	metre	yards	1.0936
	nautical mile	km	1.852
	km nautical	mile	0.5340
Area	sq.ft.	sq. metre (m^2)	0.0929
	sq.metre (m^2)	sq.ft.	10.764
Volume	US gallon	litre	3.785
	litre	US gallon	0.264
	Imp. gallon	litre	4.546
	litre	Imp. gallon	0.22
	litre	cu.ft.	0.0353
	cu.ft.	litre	28.32
Area/volume	m^2/litre	sq.ft./US gallon	40.74
	sq.ft./US gallon	m^2/litre	0.0245
	m^2/litre	sq.ft./Imp. gallon	48.93
	sq.ft./Imp. gallon	m^2/liter	0.0204
Weight	lbs	kg	0.4536
	kg	lbs	2.2046
Density	kg/litre	lbs/US gallon	8.345
	lbs/US gallon	kg/litre	0.1198
V.O.C.	g/litre	lbs/US gallon	0.0083
Pressure	atm.	bar	1.013
	atm.	kp/cm^2	1.033
	atm.	p.s.i.	14.70
	bar	atm.	0.987
	bar	kp/cm^2	1.02
	bar	p.s.i.	14.50
	kp/cm^2	atm.	0.968
	kp/cm^2	bar	0.981
	kp/cm^2	p.s.i.	14.22
	kp/cm^2	MPa	0.098
	p.s.i.	atm.	0.068
	p.s.i.	bar	0.069
	p.s.i.	kp/cm^2	0.070
Conductivity:	mS/m	µS/cm	10
	mS/m	µmho/cm	10
	µS/cm	mS/m	0.1
	µmho/cm	mS/m	0.1

Notes:
- atm. is the so called physical atmosphere (the pressure of 760 mm mercury). The technical atmosphere, at, is identical to kp/cm^2
- 1 bar = 105 Pa (Pascal) = 105 Newton/m^2
- 1 MPa (MegaPascal) = 106 Pascal = 1 MegaNewton/m^2
- 1 kilogram forces/cm^2 = 1 kp/cm^2 = 0.09807 MPa

To convert	From	To	Multiply by
Temperature	Celsius	Fahrenheit	(9/5 x °C) + 32
	Fahrenheit	Celsius	5/9 x (°F - 32)
Film thickness:	Wet	Dry	(WFT x VS%) / 100
	Dry	Wet	(DFT x 100) / VS%

Notes:
- WFT = Wet Film Thickness, DFT = Dry Film Thickness, VS% = Volume Solids

Calculation of

Theoretical spreading rate
(on completely smooth surface)

In m² per litre = $\frac{\text{VS\% x 10}}{\text{desired dft (micron)}}$

In sq.ft. per US gallon = $\frac{\text{VS\% x 16.04}}{\text{desired dft (mil)}}$

Theoretical paint consumption
(on completely smooth surface)

In litre = $\frac{\text{area (m}^2\text{) x desired dft (micron)}}{\text{VS\% x 10}}$

In US gallon = $\frac{\text{area (sq.ft.) x desired dft (mil)}}{\text{VS\% x 16.04}}$

Practical consumption
The practical consumption is influenced by
i) simple losses, by
ii) additional consumption to fill up the 'dead volume' of the surface roughness, but especially
iii) by the 'waviness' of the paint surface.

However, the term 'loss factor' is still used in parallel with the term 'consumption factor' to describe a relationship between the theoretical, calculated consumption and a practical either observed de-factor consumption or an 'aimed at' consumption.

Practical consumption = $\frac{\text{area x consumption factor}}{\text{theoretical spreading rate}}$

However, as

Consumption factor = $\frac{100}{100 - z\%}$

(z = 'loss' = simple loss + dead volume loss + waviness loss)

and

theoretical spreading rate = $\frac{\text{VS\% x 10}}{\text{DFT}}$

the practical consumption could be written as

$$\frac{\text{10 x DFT x area}}{\text{VS\% x (100 - z\%)}}$$

where it is very important to use the 'loss' for z and not the consumption factor.

Formulas for estimating surface areas of ships in sqm

Bottom (incl. boottop)

$$A = ((2 \times d) + B) \times Lpp \times P \text{ (as per Lloyd's)}$$

d = draught maximum (m)
B = breadth extreme (m)
Lpp = length between perpendiculars (m)
P = 0.90 for big tankers, 0.85 for bulk carriers, 0.70-0.75 for dry cargo liners. Values are approximate values

or

$$A = Lpp \times (Bm + 2 \times D) \times \frac{V}{Bm \times Lpp \times D}$$

d = mean draft at paint line (m)
Bm = breath moulded (m)
Lpp = length between perpendiculars (m)
V = displacement (cubic metre), corresponding to the draft

Boottop

$$A = 2 \times h \times (Lpp + 0.5 \times B)$$

h = width of boottop (m) (to be informed by owner)
Lpp = length between perpendiculars (m) (as per Lloyd's)
B = breadth extreme (m) (as per Lloyd's)

Topsides

$$A = 2 \times H \times (Loa + 0.5 \times B) \text{ (as per Lloyd's)}$$

H = height of topsides (depth - draught) (m)
Loa = length over all (m)
B = breadth extreme (m)

Weather decks

Including upper decks on superstructure, foundation, hatches and top of deck houses:

$$A = Loa \times B \times N \text{ (as per Lloyd's)}$$

Loa = length over all (m)
B = breadth extreme (m)
N = 0.91 for big tankers and bulk carriers, 0.88 for cargo liners, 0.84 for coasters, etc.

(accuracy depends on the choice of N which indicates the actual area in relation to its circumscribed rectangular)

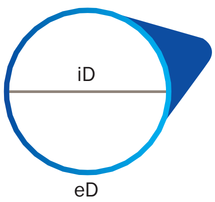
Estimating size of surfaces areas

Steel plates

Plate thickness mm	Area m^2/ton
1	254.5
2	127.2
3	84.8
4	63.6
5	50.9
6	42.4
7	36.4
8	31.8
9	28.3
10	25.4
11	23.1
12	21.2
13	19.6
14	18.2
15	17.0
16	15.9
17	15.0
18	14.1
19	13.4
20	12.7
21	12.1
22	11.6
23	11.1
24	10.6
25	10.2
26	9.8
27	9.4
28	9.1
29	8.8
30	8.5

The indicated values are for both sides. If one side only, reduce by half.

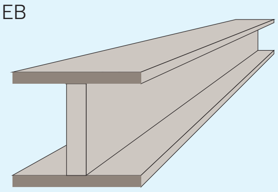
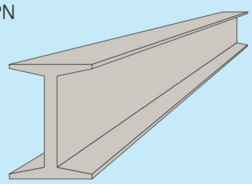
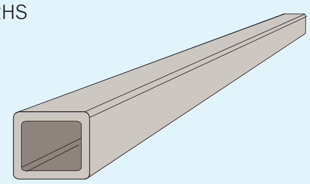
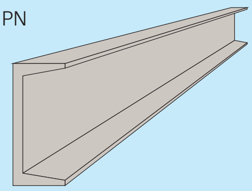
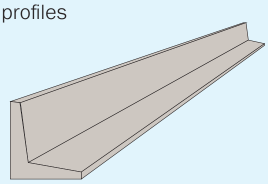
Pipes



Exterior area per meter (m^2/m):
$A = \pi \times Ed$
$\pi = 3.14$
eD = external diameter in meters

Interior area per meter (m^2/m):
$A = \pi \times eD$
$\pi = 3.14$
iD = internal diameter in meters

Estimating area of surfaces - beams and profiles, examples

Designation and shape	Size	Weight per meter, kg/m	Surface area per meter, m^2/m	Surface area per tonnes, m^2/t
HEB 	100 160 220 280 360 600	20.4 42.6 71.5 103 142 212	0.57 0.92 1.27 1.62 1.85 2.32	27.7 21.5 17.8 15.7 13.0 10.9
IPN 	80 140 200 260 340 400	5.9 14.3 26.2 41.9 68.0 92.4	0.30 0.50 0.71 0.91 1.15 1.33	51.1 35.0 27.0 21.7 16.9 14.4
RHS 	40 x 40 x 3 50 x 50 x 3 60 x 60 x 4 80 x 80 x 5 100 x 100 x 5 120 x 120 x 8	3.41 4.35 6.90 11.6 14.7 27.6	0.15 0.19 0.23 0.31 0.39 0.46	44.6 44.1 33.3 26.6 26.3 16.6
UPN 	50 80 160 240 320 400	5.6 8.6 18.8 33.2 59.5 71.8	0.23 0.31 0.55 0.78 0.98 1.18	42.2 37.1 29.0 23.3 16.5 16.5
L profiles 	25 x 4 50 x 6 75 x 7 100 x 10 100 x 16 150 x 15	1.5 4.5 7.9 15.1 23.2 33.8	0.10 0.19 0.29 0.39 0.39 0.39	66.9 43.4 36.7 25.8 16.8 17.3

In the case of the HEB beam, the first illustration, height and breadth are equal up to the size of 280. The ‘size’ is the height and equal to the profile number.

- For IPN beams, the ‘size’ is the height and equal to the profile number
- For UPN beams, the ‘size’ is the height and equal to the profile number
- For L-profiles, the two flanges are reckoned equal, the second digit being the thickness of the steel

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