How to select the right paint system

Guidelines for coating protection
in accordance with ISO 12944

Introduction

The purpose of this study is to help you select the optimal Hempel coating system to protect your structure against corrosion.

All steel structures, facilities and installations exposed to atmosphere, staying under water or in soil, suffer because of corrosion and consequently require protection from the harms of corrosion during their lifetime. Throughout this study you will find important information regarding paint technology, criteria for right paint selection and surface preparation requirements.

This study has been prepared in accordance with the latest edition of the International Standard ISO 12944 'paints and varnishes – corrosion protection of steel structures by protective paint systems'. Hempel's own guidelines and recommendations for coating protection technology are also included.

Outlined at the end of this study are generic coating systems recommended by Hempel for different corrosive environments. This study is to be considered as a guide and to be of no binding.

Table of contents

1. How to select the right paint system

Selecting the correct paint system for protection against corrosion requires a variety of factors to be taken into account to ensure that the most economical and best technical solution is achieved. For each project the most important factors to consider before selecting a protective coating are:

a. Environmental corrosivity

When selecting a paint system it is vitally important to work out the conditions in which the structure, facility or installation is to operate. To establish the effect of environmental corrosivity, the following factors must be taken into account:

- humidity and temperature (service temperature and temperature gradients)
- the presence of UV radiation (present in sunlight)
- chemical exposure (e.g. specific exposure in industrial plants)
- mechanical damage (impact, abrasion etc)

In the case of buried structures the ground conditions which they are exposed to must be considered. The dampness and pH of the terrain and biological exposure to bacteria and micro-organisms are of critical importance. In the case of water, the type and chemical composition of the water present is also significant.

The corrosive aggressiveness of the environment will have an effect on:

- the type of paint used for protection
- the total thickness of a paint system
- the surface preparation required
- minimum and maximum recoating intervals

Note that the more corrosive the environment, the more thorough the surface preparation required. The recoating intervals must also be strictly observed.

Part 2 of ISO 12944 standard gives the corrosion classifications for atmospheric conditions, soil and water. This standard is a very general evaluation based on the corrosion rate for carbon steel and zinc. It does not reflect specific chemical, mechanical or temperature exposure. However the standard specification may still be accepted as a good indicator for paint system projects as a whole.

ISO 12944 distinguishes 5 basic atmospheric corrosivity categories:	
C1	Very low
C2	Low
C3	Medium
C4	High
C5-I	Very high (Industrial)
C5-M	Very high (Marine)

Corrosivity category	Environment examples		Hempel's paint systems
	Exterior	Interior	
C1 very low	-	Heated buildings with a clean atmosphere such as offices, shops, schools, hotels	Page 24 - 25
C2 low	Atmosphere contaminated to a small extent, mainly rural regions	Buildings which are not heated, where condensation may occur e.g. storehouses, sports halls	Page 24 - 25
C3 medium	Industrial and urban atmosphere with an average sulphur oxide (IV) contamination level. Inland areas of low salinity	Production space of high humidity and certain air contamination e.g. foodstuff plants, laundries, breweries, dairies	Page 26 - 27
C4 high	Industrial areas and inland areas of medium salinity	Chemical plants, swimming pools, ship repair yards	Page 28 - 29
C5-I very high (industrial)	Industrial areas of high humidity and aggressive atmosphere	Buildings and areas of almost constant condensation and high contamination	Page 30 - 31
C5-M very high (marine)	Inland areas and offshore areas of high salinity	Buildings and areas of almost constant condensation and high contamination	Page 32 - 33

The categories for water and soil according to the ISO 12944 standard are shown as:

Corrosivity categories	Environment	Examples of environments and structures	Hempel's paint systems
Im1	Fresh water	River installations, hydroelectric power plants	Page 34 - 35
Im2	Sea or brackish water	Seaports with the following structures: sluice gate, locks (water steps), water stilts, piers, offshore structures	
Im3	Soil	Underground tanks, steel stilts, pipelines	

b. A type of protected surface

Designing a coating system normally involves dealing with constructional materials such as steel, hot dipped galvanized steel, spray-metallized steel, aluminum or stainless steel. The surface preparation, the paint products used (particularly the primer) and the total system thickness will depend mainly on the constructional material to be protected.

c. The durability required for a paint system

The lifetime of a paint system is assumed to be the period of time which passes until maintenance is required for the first time after application. ISO 12944 specifies a range of three time frames to categorize durability:

Low - L	2 to 5 years
Medium - M	5 to 15 years
High - H	more than 15 years

d. Planning the paint application process

The building schedule and the various stages of construction of any particular project determine how and when the paint system needs to be applied. Consideration needs to be given to materials at their prefabrication stage, when components are being prefabricated both off and on site and when building stages are complete.

It is necessary to plan the job so that surface preparation and the drying/curing time of paint products in relation to temperature and humidity are considered. Also if one stage of construction takes place in a protected workshop environment and the next stage then takes place on site, recoating intervals must also be taken into account.

Hempel's skilled personnel is always available to assist its customers in selecting the most adequate coating system for the customer's needs and requirements. For further information, please contact your local Hempel representative.

2. Surface preparation

2.1 Surface preparation grades

There are many ways to classify steel surface preparation grades but this study focuses on those outlined below.

A. Grades of a surface according to the ISO 8501-1 standard

Standard surface preparation grades for primary surface preparation by abrasive blasting methods	
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 matter1. It shall have a uniform metallic color.
Sa 2½	**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 matter1. 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 matter1. 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 matter1.

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 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.

Standard preparation grades for primary surface preparation by hand cleaning	
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 below)

Notes:
1. Preparation grade St 1 is not included as it corresponds to a surface unsuitable for painting.

B. Surface preparation grades after high pressure water cleaning

Surface preparation grades by high pressure water cleaning should not only include the cleanliness grade but also the flash rust grade, since flash rusting may occur on cleaned steel during the drying period. There are several ways to classify the degree to which a steel surface is prepared after high pressure water cleaning.

This study has used the ISO 8501-4 surface preparation grade standard using high pressure water jetting: 'Initial surface conditions, preparation grades and flash rust grades in connection with high pressure water jetting'.

The standard applies to surface preparation by high pressure water cleaning for a paint coating. It distinguishes three levels of cleanliness with reference to visible contaminants (Wa 1 – Wa 2½) such as rust, mill scale, old paint coatings and other foreign matter.

Description of the surface after cleaning:	
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. Discoloration of the surface can be present where the original coating was not intact. The grey or brown/black discoloration observed on pitted and corroded steel cannot be removed by further water jetting

Description of the surface appearance relating to three grades of flash rust:	
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 discoloration) 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

2.2 Types of surfaces

A. Steel surfaces

To guarantee that a coating system delivers long lasting protection, it is essential to ensure that the right surface preparation is carried out before any paint is applied. For this reason the initial surface condition of the steel needs to be evaluated.

Generally speaking, the condition of a steel surface prior to painting falls into one of the three following categories:

a) a bare steel structure with no previous protective paint coatings
b) a steel surface coated with a shopprimer
c) a steel surface coated with a paint system which needs to be maintained

These categories are outlined in more detail below.

a. A bare steel structure with no previous protective coatings

Steel surfaces which have never been protected by paint coatings may be covered to a varying extent by rust, mill scale or other contaminants (dust, grease, ionic contamination/ soluble salts, residues etc.).

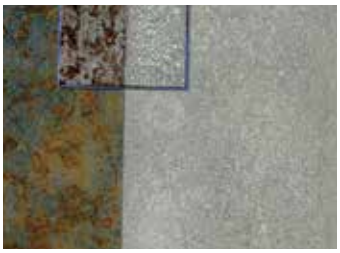
The initial condition of such surfaces is defined by ISO 8501-1 standard: 'Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness'.

ISO 8501-1 standard identifies four initial conditions for steel: A, B, C, D:

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 can be removed by scraping, 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	

The corresponding photographs show levels of corrosion, preparation grades of unprotected steel substrates and steel substrates after completely removing previous coatings.

A GRADES
a 2½

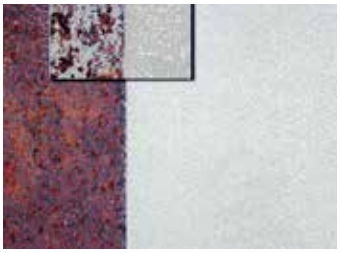


B GRADE
Sa 2½

C GRADE
Sa 2½

D GRADE
Sa 2½

A GRADE
Sa 3



B GRADE
Sa 3

C GRADE
Sa 3

D GRADE
Sa 3

b. A steel surface covered with shopprimers

The main purpose of applying shopprimers is to protect steel plates and structural components used in the prefabrication stage, or in storage before a main paint system is applied. A shopprimer film thickness normally equals 20-25 µm (these figures are quoted for a smooth test panel). Steel plates and structural components coated with shopprimers can be welded.

Hempel offers the following shopprimer in North America:

Hempel's ZS 15890

(protection period - 4 to 6 months) is a solvent-borne zinc silicate shopprimer designed for automatic spray application.

Surfaces coated with a shopprimer must be prepared correctly prior to the application of a finishing paint system; this is termed 'second surface preparation'. A shopprimer may need to be partially or completely removed. The second surface preparation will be determined by the finishing paint system and two key factors need to be taken into account:

- the compatibility of an applied shopprimer and a finishing paint system
- the surface profile achieved during preparation prior to a shopprimer application, i.e. whether the profile is suitable for a finishing paint system

A surface coated with a shopprimer should always be thoroughly washed with water and detergent (e.g. Hempel's light clean 99350) at 15-20 MPa, and then rinsed carefully prior to a paint system application. Corrosion and damage due to welding spots must be cleaned to the preparation grade as specified in the ISO 8501-1 standard.

c. A steel surface coated with a paint system which needs to be maintained

The condition of an existing paint system must be assessed using the degradation grade according to the standard and this must be done each time maintenance work is carried out. It will need to be determined whether the system should be completely removed or whether parts of the coating can remain. For the different amounts of surface preparation required refer to ISO 8501-2 standard: 'Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Preparation grades of previously coated steel substrates after localized removal of previous coatings'.

B. Hot dipped galvanized steel, aluminum and stainless steel surfaces

In addition to standard steel, other non-iron materials can be used in construction such as hot dipped galvanized steel, aluminum or high-alloy steels. All of them require a separate approach in terms of surface preparation and the selection of a paint system.

a. Hot dipped galvanized steel

When galvanized steel is exposed to the atmosphere, zinc corrosion products form on its surface. These products vary in their composition and adhesion and influence therefore the adhesive properties of applied paint systems. It is generally considered that the best surface for painting is one of pure (within hours of the galvanization process) or seasoned zinc. For stages in between it is recommended that the zinc corrosion products are removed by washing the surface with Hempel's alkaline cleaner. This can be carried out using a mixture of 20 liters of pure water to half a liter of Hempel's light clean 99350 detergent.

The mixture must be applied to the surface and then rinsed off after half an hour, preferably at high pressure. If necessary washing should be combined with scrubbing using a special hard nylon bristle brush, abrasive paper or the surface cleaned by an abrasive (glass balls, sand, etc.). For coating systems in lower corrosion classes, special adhesion primers are recommended. For coating systems in higher corrosion classes, surface preparation should include mechanical preparation of the surface, preferably by abrasive sweep blasting with a mineral abrasive.

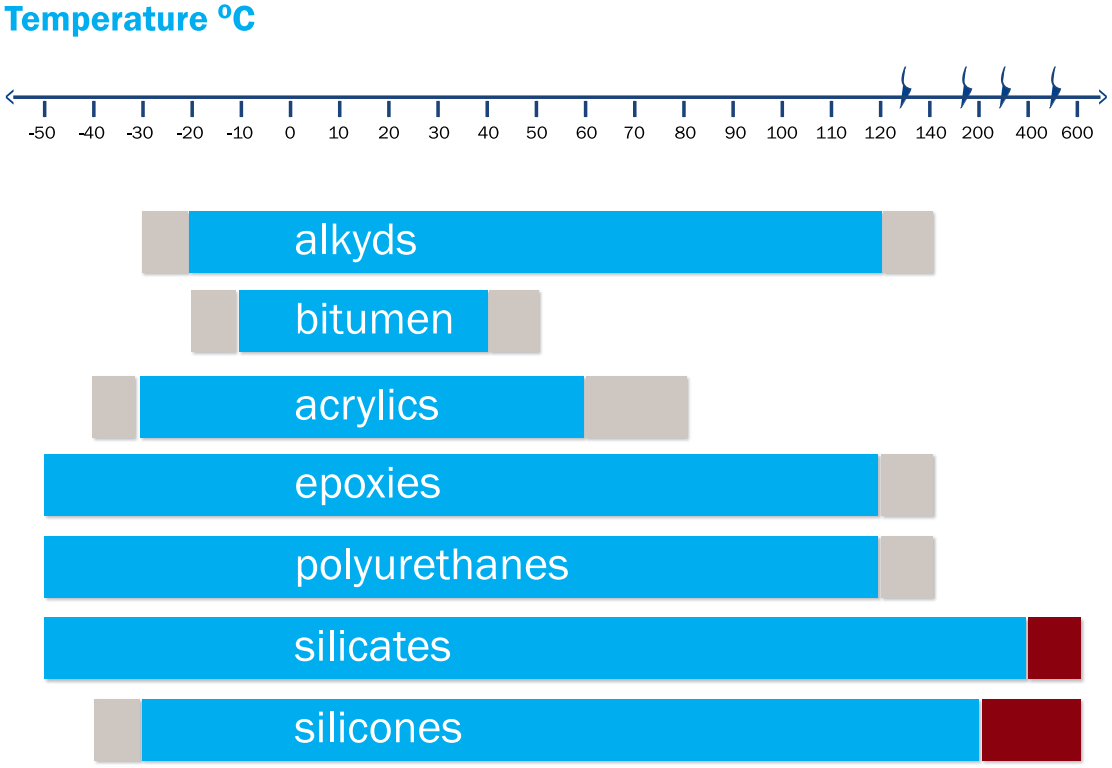
b. Aluminum and stainless steel

In the case of aluminum and stainless steel, the surface should be cleaned with fresh water and a detergent, then rinsed off thoroughly by pressure washing with fresh water. To obtain better adhesion for the paint system it is recommended that abrasive blasting is carried out with a mineral abrasive or special brushes are used.

For further information and thorough explanations on processes and procedures of surface preparation, you can contact your local Hempel representative.

3. Maximum service temperatures

Paint products have different resistances to temperatures depending on the binder and pigments used. The temperature resistance of individual paint types is shown below.



Suitable for continuous dry service

Suitable for short temporary service only

Suitability will depend on pigmentation. Above 752°F/400°C only aluminum pigment is suitable

4. Hempel paints

4.1. Generic types

Hempel offers the following main types of paint:

One component:
a) Alkyd
b) Acrylic
c) Polysiloxane (for high temperature service)

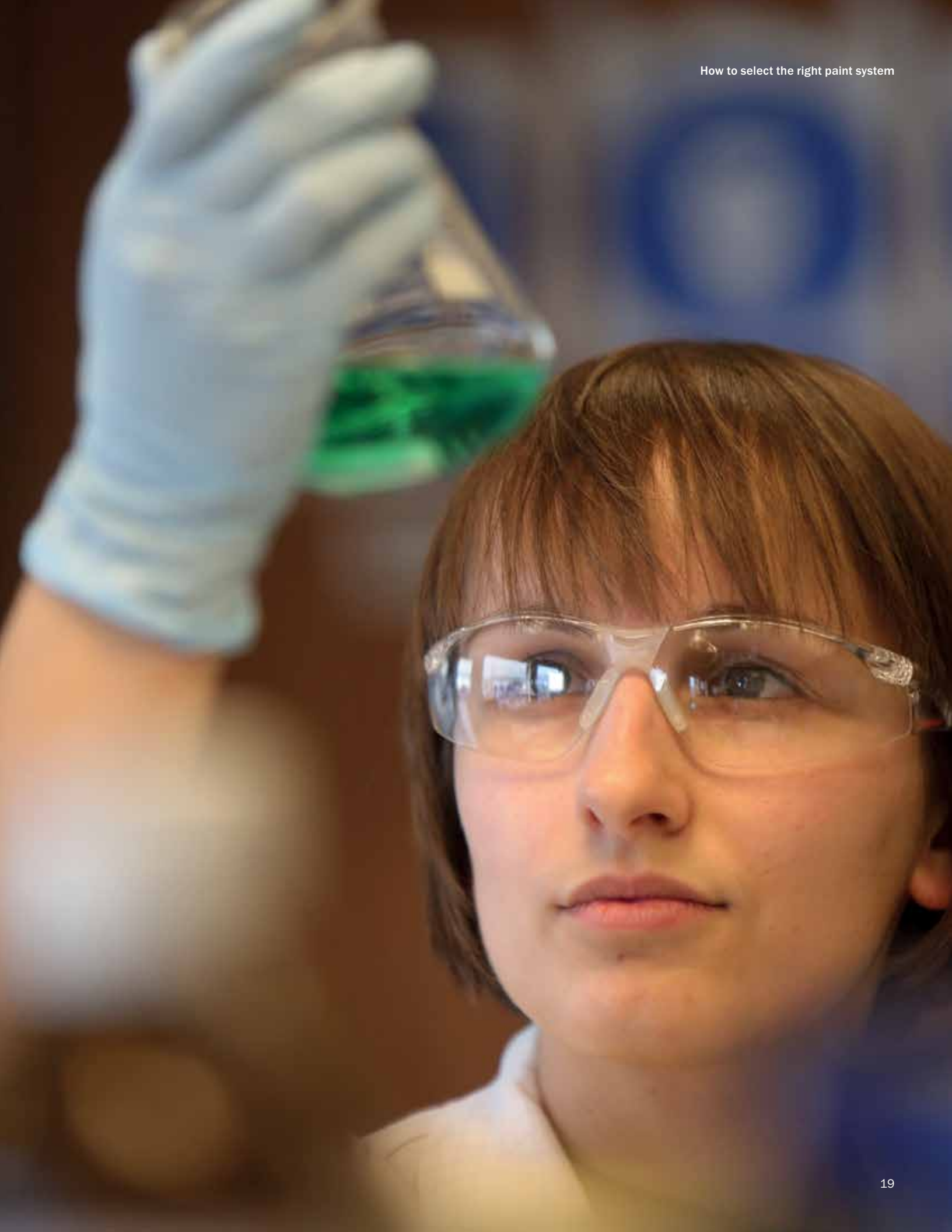
Two components:
a) Epoxy (pure and modified)
b) Polyurethane
c) Zinc silicate
d) Polysiloxane hybrids

4.2. Explanation of Hempel product names

Generally the name of a Hempel paint is based on a product name and a five-digit number e.g. Hempatex Hi Build 46410. The product name denotes the group and generic type to which the paint belongs as shown in the following table:

Physically drying:	
Hempatex	Acrylic (solvent-borne)
Hemucryl	Acrylic (waterborne)

Chemically curing:	
Hempalin	Alkyd, modified alkyd (oxidatively drying)
Hemulin	Alkyd (waterborne)
Hempadur	Epoxy, modified epoxy (solvent-borne, solvent-free)
Hemudur	Epoxy (waterborne)
Hempathane	Polyurethane (solvent-borne)
Hemuthane	Polyurethane (waterborne)
Galvosil	Zinc silicate
Hempaxane	Polysiloxane hybrid (solvent-borne)



A 5-digit number identifies the remaining properties of a product. The first two digits relate to the principal function and the generic type. The third and fourth digits are serial numbers. The fifth digit identifies specific formulas with the same product, e.g. high temperature curing/low, medium temperature curing, conformity to local legislation. Therefore, the first four digits define the end-user performance, i.e. the dried, cured paint material. The fifth digit usually relates to the conditions of application, however, may also be used purely for logistic reasons.

Example:
Hempatex Enamel 56360

5	_	_	_	_	Topcoat
_	6	_	_	_	Physically drying
_	_	3	6	_	Serial number
_	_	_	_	0	Standard formula

First digit:	Function:
0_ _ _ _	Clear varnish, thinner
1_ _ _ _	Primer for steel and other metals
2_ _ _ _	Primer for non-metallic substrates
3_ _ _ _	Paste product, high-solids material
4_ _ _ _	Intermediate coating, high-build coating used with/without primer and finishing coat
5_ _ _ _	Finishing coat
6_ _ _ _	Miscellaneous
7_ _ _ _	Antifouling paint
8_ _ _ _	Miscellaneous
9_ _ _ _	Miscellaneous

Second digit:	Generic type:
_0_ _ _	Asphalt, pitch, bitumen, tar
_1_ _ _	Oil, oil varnish, long-oil alkyd
_2_ _ _	Medium to long-oil alkyd
_3_ _ _	Short-oil alkyd, epoxyester, silicone alkyd, urethane alkyd
_4_ _ _	Miscellaneous
_5_ _ _	Reactive binder (non-oxidative), one or two-component
_6_ _ _	Physically drying binder (solvent-borne) (other than - 0 - - -)
_7_ _ _	Miscellaneous
_8_ _ _	Aqueous dispersion, thinner
_9_ _ _	Miscellaneous

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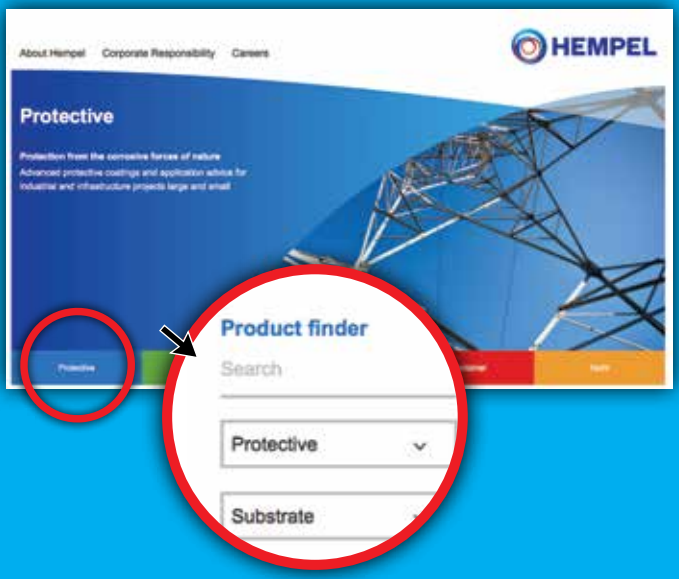
Hempel's Product and Safety Data Sheets are available on local Hempel websites in local languages. To find local Product Data Sheets search in product finder.



4.3. Hempel's shade identification

Paints, especially primers, are identified by a 5-digit number, 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 numbers do not directly correlate to official color standard numbers. However, in the case of finishing paints or other selected products, shades corresponding to specific official standard shades such as RAL, BS, NCS etc. may be established.

Shade identification example:
Hempadur Mastic 45880

Paint Hempadur Mastic 45880 in Hempel standard shade 12170 – light grey

5. Useful definitions

There are several useful definitions and terms used in coating protection technology. We provide you here with few necessary terms that you should be acquainted with when dealing with paints:

Volume solids
The volume solids (VS) figure expresses as a percentage the ratio of:

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

The stated figure has been determined as the ratio between dry and wet film thickness of the coating applied in the indicated thickness under laboratory conditions, where no paint loss has been encountered.

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:

$$\frac{1604 \times \text{Volume Solids \%}}{\text{Dry film thickness (mils)}} = \text{sq. ft. per gallon}$$

1 mil = 25.4 microns

Practical consumption
The practical consumption is estimated by multiplying the theoretical consumption with a relevant consumption factor (CF). The consumption factor or the practical consumption cannot be stated in the product data sheet because it depends on a number of external conditions such as:`

a. Waviness of paint film

When paint is manually applied the film will show some waviness on the surface. It will also have an average thickness higher than the specified dry film thickness in order to fulfil the 80:20 rule for example. This means the paint consumption will be higher than the theoretically calculated amount if you want to reach the minimum specified film thickness.

b. Size and shape of the surface

Complex and small-sized surfaces will lead to higher consumption through overspray, than the square, flat area which was used to work out the theoretical calculation.

c. Surface roughness of the substrate

When a substrate has a particularly rough surface this creates a 'dead volume' which uses more paint than if the surface was smooth and this will affect any theoretical calculations. In the case of shopprimers with a thin film, this has the effect of seemingly larger surface causing higher consumption as the paint film covers irregular surface hollows.

d. Physical losses

Factors such as residues in cans, pumps and hoses, discarded paint due to exceeded pot life, losses due to atmospheric conditions, insufficient skills of a painter etc. will all contribute to a higher consumption.

6. Hempel paint systems

Recommended paint systems for various atmospheric corrosivity categories & other types of environments (in accordance with ISO 12944-5:2007)

C1/C2 corrosivity category

Hempel paint systems
Sample systems corresponding to C1/C2 corrosivity categories*

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
2 - 5 years	1	SB Polyurethane	1× Hempathane HS 55610	80
		Total DFT		**80 µm**
5 - 15 years	1	SB Polyurethane	1× Hempathane HS 55610	120
		Total DFT		**120 µm**
> 15 years	1	WB Acrylic	2× Hemucryl Primer HB 18032	100
		WB Acrylic	1× Hemucryl Enamel HB 58030	60
		Total DFT		**160 µm**
	2	SB Epoxy	1× Hempadur Mastic 4588 Series	160
		Total DFT		**160 µm**
	3	SB Epoxy	1× Hempadur Fast Dry 17410	100
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**160 µm**
	4	SB Polyurethane	1× Hempathane HS 55610	160
		Total DFT		**160 µm**

*For places where blasting as secondary surface preparation is not possible after production, the use of shopprimed steel is an option. Ask Hempel for more specific guidelines regarding optimum choice of shopprimer and need for secondary surface preparation.

SB = Solvent-borne
WB = Waterborne
DFT = Dry Film Thickness

C3 corrosivity category

Hempel paint systems
Sample systems corresponding to C3 corrosivity categories*

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
2 - 5 years	1	SB Polyurethane	1× Hempathane HS 55610	120
		Total DFT		**120 µm**
5 - 15 years	1	WB Acrylic	1× Hemucryl Primer HB 18032	100
		WB Acrylic	1× Hemucryl Enamel HB 58030	60
		Total DFT		**160 µm**
	2	SB Polyurethane	1× Hempathane HS 55610	200
		Total DFT		**200 µm**
	3	SB Epoxy	1× Hempadur Fast Dry 17410	100
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**160 µm**
> 15 years	1	WB Acrylic	1× Hemucryl Primer HB 18032	100
		WB Acrylic	1× Hemucryl Enamel HB 58030	100
		Total DFT		**200 µm**
	2	SB Epoxy	1× Hempadur Fast Dry 17410	120
		SB Polyurethane	1× Hempathane HS 55610	80
		Total DFT		**200 µm**
	3	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	80
		SB Polyurethane	1× Hempathane HS 55610	80
		Total DFT		**160 µm**
	4	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	80
		WB Acrylic	1× Hemucryl Enamel HB 58030	80
		Total DFT		**160 µm**

* For places where blasting as secondary surface preparation is not possible after production, the use of shopprimed steel is an option. Zinc silicate based shopprimers e.g. Hempel's Shopprimer ZS 15890 is preferred, especially for later overcoating with paints containing zinc. Ask Hempel for more specific guidelines regarding the optimum choice of shopprimer and the need for secondary surface preparation.

SB = Solvent-borne
WB = Waterborne
DFT = Dry Film Thickness

C4 corrosivity category

Hempel paint systems

Sample systems corresponding to C4 corrosivity categories*

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
2 - 5 years	1	WB Acrylic	2× Hemucryl Primer HB 18032	140
		WB Acrylic	1× Hemucryl Enamel HB 58030	60
		Total DFT		**200 µm**
	2	SB Epoxy	1× Hempadur Fast Dry 17410	120
		SB Polyurethane	1× Hempathane HS 55610	80
		Total DFT		**200 µm**
	3	SB Epoxy	2× Hempadur Mastic 4588 Series	240
		Total DFT		**240 µm**
5 - 15 years	1	SB Epoxy	2× Hempadur Fast Dry 17410	180
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**240 µm**
	2	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1× Hempadur Fast Dry 17410	80
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**200 µm**
> 15 years	1	SB Epoxy	2× Hempadur Fast Dry 17410	220
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**280 µm**
	2	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1× Hempadur Fast Dry 17410	120
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**240 µm**
	3	SB Zinc Silicate	1× Hempel's Galvosil 15680	60
		SB Epoxy	1× Hempadur Mastic 4588 Series	120
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**240 µm**
	4	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1× Hempadur Fast Dry 17410	120
		SB Polysiloxane	1× Hempaxane Light 5503A	60
		Total DFT		**240 µm**

* For places where blasting as secondary surface preparation is not possible after production, the use of shopprimed steel is an option. Zinc silicate based shopprimers e.g. Hempel's Shopprimer ZS 15890 is preferred, especially for later overcoating with paints containing zinc. Ask Hempel for more specific guidelines regarding the optimum choice of shopprimer and the need for secondary surface preparation.

SB = Solvent-borne
WB = Waterborne
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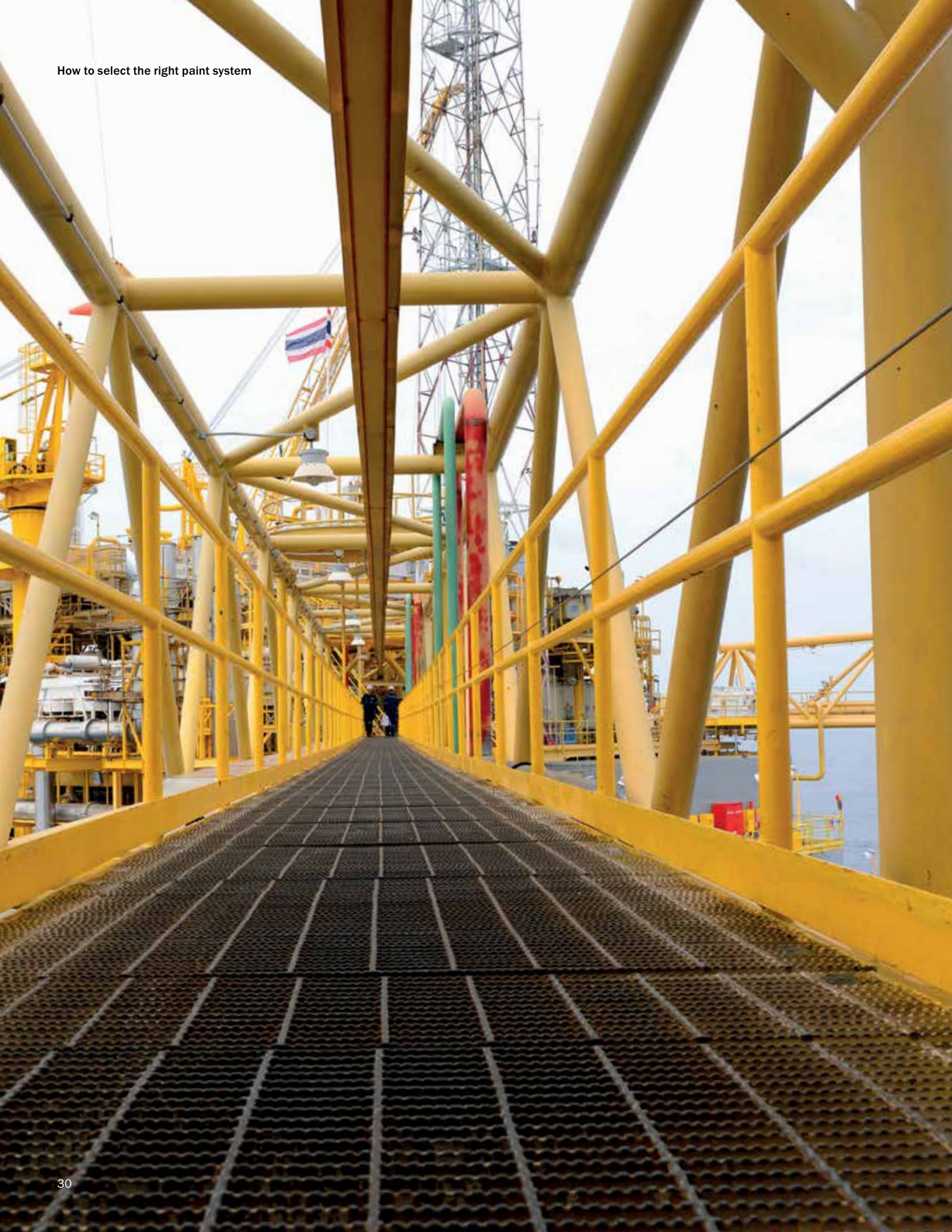

C5-I corrosivity category

Hempel paint systems
Sample systems corresponding to C5-I corrosivity categories*

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
5 - 15 years	1	SB Epoxy	2× Hempadur Mastic 4588 Series	300
		Total DFT		**300 µm**
	2	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1× Hempadur Fast dry 17410	120
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**240 µm**
> 15 years	1	SB Epoxy	2× Hempadur Mastic 4588 Series	260
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**320 µm**
	2	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	2× Hempadur Fast dry 17410	200
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**320 µm**
	3	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	2× Hempadur 4588 Series	200
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**320 µm**
	4	SB Zinc Silicate	1× Hempel's Galvosil 15680	60
		SB Epoxy	1× Hempadur Mastic 4588 Series	200
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**320 µm**

* For places where blasting as secondary surface preparation is not possible after production, the use of shopprimed steel is an option. Zinc silicate based shopprimers e.g. Hempel's Shopprimer ZS 15890 is preferred, especially for later overcoating with paints containing zinc. Ask Hempel for more specific guidelines regarding the optimum choice of shopprimer and the need for secondary surface preparation. .

SB = Solvent-borne
WB = Waterborne
DFT = Dry Film Thickness

C5-M corrosivity category

Hempel paint systems
Sample systems corresponding to C5 marine corrosivity category*

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
5 - 15 years	1	SB Epoxy	1× Hempadur Mastic 4588 Series	150
		SB Epoxy	1× Hempadur Mastic 4588 Series	150
		Total DFT		**300 µm**
	2	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1× Hempadur Fast dry 17410	120
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**240 µm**
	3	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1× Hempadur 4588 Series	120
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**240 µm**

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
> 15 years	1	SB Epoxy	1× Hempadur Mastic 4588 Series	200
		SB Polyurethane	1× Hempathane HS 55610	120
		Total DFT		**320 µm**
	2	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1x Hempadur Mastic 4588 Series	200
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**320 µm**
	3	SB Zinc Silicate	1× Hempel's Galvosil 15680	60
		SB Epoxy	1× Hempadur Mastic 4588 Series	200
		SB Polyurethane	1× Hempathane HS 55610	60
		Total DFT		**320 µm**
	4	SB Zinc Epoxy	1× Hempadur Avantguard 550 or 750	60
		SB Epoxy	1× Hempadur Mastic 4588 Series	200
		SB Polysiloxane	1× Hempaxane Light 5503A	60
		Total DFT		**320 µm**

* For places where blasting as secondary surface preparation is not possible after production, the use of shopprimed steel is an option. Zinc silicate based shopprimers e.g. Hempel's Shopprimer ZS 15890 is preferred, especially for later overcoating with paints containing zinc. Ask Hempel for more specific guidelines regarding the optimum choice of shopprimer and the need for secondary surface preparation.

SB = Solvent-borne
WB = Waterborne
DFT = Dry Film Thickness

Immersed structures

SB = Solvent-borne
WB = Waterborne
DFT = Dry Film Thickness

Hempel paint systems

1. For steel structures immersed in water (excluding potable water) or buried in soil

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
5 - 15 years	1	Epoxy	Hempadur Quattro 17634	190
		Epoxy	Hempadur Quattro 17634	190
		Total DFT		**380 µm**
	2	Epoxy	Hempadur Mastic 4588 Series	190
		Epoxy	Hempadur Mastic 4588 Series	190
		Total DFT		**380 µm**
	3	Epoxy GF	Hempadur Multi-strength GF 3587a	400
		Total DFT		**400 µm**
> 15 years	1	Epoxy	Hempadur Multi-strength 45751/3	150
		Epoxy	Hempadur Multi-strength 45751/3	175
		Epoxy	Hempadur Multi-strength 45751/3	175
		Total DFT		**500 µm**
	2	Epoxy GF	Hempadur Multi-strength GF 3587a	300
		Epoxy GF	Hempadur Multi-strength GF 3587a	300
		Total DFT		**600 µm**

2. For steel structures immersed in potable water (drinking water)

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
5 - 15 years	1	Epoxy (solventfree)	Hempadur 35530	200
		Epoxy (solventfree)	Hempadur 35530	200
		Total DFT		**400 µm**
	2	Epoxy (solventfree)	Hempadur 35530	400
		Total DFT		**400 µm**

3. Tank lining for fuels (crude oil, jet fuel, gasoline etc.)

Estimated lifetime	System no	Paint type	Hempel paint system samples	Thickness (micron) µm
> 15 years	1	Epoxy (Phenolic)	Hempadur 85671	100
		Epoxy (Phenolic)	Hempadur 85671	100
		Epoxy (Phenolic)	Hempadur 85671	100
		Total DFT		**300 µm**

Heat resistant structures

Hempel paint systems
For steel structures that need to be heat resistant

Paint type	Hempel paint system samples	Thickness (micron) µm
Zinc Silicate	Hempel's Galvosil 15680	75
Silicone	Hempel's Silicone Aluminum 56913	25
Silicone	Hempel's Silicone Aluminum 56913	25
Total DFT		**125 µm**

Maximum heat resistance: 932°F/ 500°C

Paint type	Hempel paint system samples	Thickness (micron) µm
Zinc Silicate	Hempel's Galvosil 15680	80
Total DFT		**80 µm**

Maximum heat resistance: 932°F/ 500°C

Paint type	Hempel paint system samples	Thickness (micron) µm
Silicone	Versiline CUI 56990	150
Silicone	Versiline CUI 56990	150
Total DFT		**300 µm**

1200°F/ 649°C

Some of the Hempel's systems have been tested according to ISO 12944-6. For further information please contact your local Hempel office.

Hempathane HS 55610 can be replaced by other Hempel's PU in the assortment such as (but not limited to) Hempathane T/C 55210, Hempel's Polyenamel 55102 provided the maximum DFT allowed for each product is not exceeded. For this reason, please check the relevant PDS or consult your nearest Hempel office.

Notes

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Since 1915 Hempel has been producing protective coatings that help customers to safeguard their assets while keeping them looking their best. Today we are a world-leading supplier of trusted solutions in the Protective, Decorative, Marine, Container and Yacht markets. Employing over 5,500 people, across 80 countries worldwide, with 28 factories and more than 150 stock points globally. This includes many recognized brands like Crown Paints, Neogard and Jones-Blair.

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