Hot Dip Galvanizing and corrosion categories

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In which corrsion categories could galvanized steel be used? This question is frequently asked when only a specific corrosion category is specified. Such a specification is insufficient, since corrosion categories only indicates fairly wide limits for the environment where the construction will be exposed, but without specifying the type of protection or life time for the construction. A more detailed specification for the corrosion protection is needed, considering the requirements regarding durability and time to first maintenance.

This information sheet is intended to provide information about the possibilities to use hot-dip galvanizing in different corrosion categories.

Corrosion rates

EN ISO 12944-2 specifies the corrosion categories C1 to CX. The corrosion categories show the corrosion loss on zinc and steel as shown in table 2. Table 3 provides examples of related corrosion environments. Corrosion rates of common structural steel and zinc are based partly on results from field exposure, partly on practical experience from galvanized steel structures.

Table 4 presents the life time of the zinc coating with layer thicknesses according to standard EN ISO 1461:2022. The table also include thicknesses of at least 115, 165 and 215 microns, that can be achieved on steel with specified silicon content and thickness above 6 mm. Some comments on the different corrosion categories are given below:

Corrosion category C1, C2 and C3

Hot dip galvanizing results in a corrosion protection which normally has a very long life in these corrosion categories and can be used without any problems.

Corrosion Category C4

The lowest coating thicknesses of 45 microns, which are created on thin parts, results in a moderate life span in this corrosion category. However, this does not lead to any problems if the steel parts are interchangeable, so that regalvanizing is possible, or if the parts are accessible for maintenance with other anti-corrosion treatment.

If replacement or maintenance is not possible, it may be desirable to have a corrosion protection with a very long durability. This can be achieved with coating thicknesses of 115, 165 or 215 microns, as shown in Table 4.These large thicknesses can be reached only if previously agreed with the galvanizer, and when reactive steel has been choosen.

Coating thickness (µm)	Optimal silicon level (%)	Silicon range (%)
Fe/Zn 115	0,18	0,15-0,21
Fe/Zn 165	0,25	0,22-0,28
Fe/Zn 215	0,32	0,29-0,35

Table 1.Optimal and range values for silicon when higher coating thicknesses are required.

Requirements of a minimum of 115 microns in local coating thickness can also be met on steel with low silicon content when the steel before galvanizing is sandblasted so the the surface roughness is minimum R_a $12_{1/2}$ microns.

Corrosion category C5

This category includes the most corrosive atmospheric conditions that may occur locally at the western coasts or at particularly polluted industrial and urban areas. The thinnest zinc coatings will have shorter life under these conditions, and duplex treatment (=galvanizing + paint) might be needed.

In water and soil

EN ISO 12944-2 also contains corrosion categories for steel structures which are immersed in water (Im1, Im2) or buried in soil (Im3), but it is here difficult to give general guidelines for when hot dip galvanizing can be used alone, or when it is necessary to use duplex treatment. The corrosion conditions should be evaluated in each separate case.

It will usually be necessary to use duplex to achieve long-term protection in the following environments:

- In almost constantly moist environment
- In highly acidic or highly alkaline environments
- In more corrosive soils as loamy soil and peat and peat soil

By proper pre-treatment of zinc surfaces prior to coating, as described in Nordic Galvanizers ” Galvanizing Handbook”, it is possible to obtain adequate durability for most conditions.

Corrosivity category	Mass loss for surface unit and thickness reduction (1 year of exposure)			
	Steel		Zinc	
	Mass loss (g/m^2)	Thickness reduction (µm)	Mass loss (g/m^2)	Thickness reduction (µm)
C1	≤ 10	≤ 1,3	≤ 0,7	≤ 0,1
C2	> 10 till 200	> 1,3 till 25	> 0,7 till 5	> 0,1 till 0,7
C3	> 200 till 400	> 25 till 50	> 5 till 15	> 0,7 till 2,1
C4	> 400 till 650	> 50 till 80	> 15 till 30	> 2,1 till 4,2
C5	> 650 till 1500	> 80 till 200	> 30 till 60	> 4,2 till 8,4
CX	> 1500 till 5500	> 200 till 700	> 60 till 180	> 8,4 till 25

Table 2. Atmospheric corrosion categories

Corrosivity category	Corrosivity	Examples of environments	
		Outdoor	Indoor
C1	Very little		Heated buildings with dry air and insignificant amounts of pollutants, e.g. offices, shops, schools, hotels.
C2	Little	Environments with low levels of polution. Mainly rural setting.	Unheated buildings with changing temperature and humidity. Low frequency off moisture condensation and low content air pollution, e.g. sports halls, warehouses.
C3	Moderate	Atmosphere with a certain amount of salt or moderate amounts of air pollution. Urban areas and slightly industrialized areas. Areas with moderate influence from the coast.	Buildings with moderate humidity and certain amount of air pollution from production processes, e.g. breweries, dairies, laundries, heated ice rinks.
C4	Large	Atmospheres with moderate amount salt or palpable amounts air pollution. Industry and coastal areas.	Buildings with high humidity and large amount air pollution from production processes, e.g. chemical industries, swimming pools, shipyards, non-heated ice rinks.
C5	Very large	Industrial areas with high humidity and aggressive atmosphere and coastal areas with a large amount salt in the air.	Buildings with almost permanent moisture condensation and large amount air pollution.
CX	Extreme	Industrial areas with extreme humidity and aggressive tropical or sub-tropical atmosphere. Offshore areas with a large amount salt in the air.	Industrial buildings with extreme humidity and aggressive atmosphere.

Table 3. Examples of typical corrosion environments according to EN ISO 12944-2.

Coating thicknesses according to EN ISO 1461[1]		Life time of zinc coating in different corrosion categories				
Steel thickness mm	**(Local coating thickness[3]) Mean thickness[4] µm**	**C1**	**C2**	**C3**	**C4**	**C5[5]**
Steel > 6 mm	(70) 85	100+	100-100+	40-100+	20-40	10-20
Steel > 3 - ≤ 6 mm	(55) 70	100+	100-100+	33-100	17-33	8-17
Steel ≥ 1,5 - ≤ 3 mm	(45) 55	100+	78-100+	26-78	13-26	6-13
Steel < 1,5 mm	(35) 45	100+	64-100+	21-64	11-21	5-11
Castings ≥ 6 mm	(70) 80	100+	100-100+	38-100+	19-38	10-19
Castings < 6 mm	(60) 70	100+	100-100+	33-100	17-33	8-17
Steel > 6 mm Special[2]	(100) 115	100+	100+	55-100+	27-55	14-27
Steel > 6 mm Special[2]	(145) 165	100+	100+	78-100+	39-78	20-39
Steel > 6 mm Special[2]	(190) 215	100+	100+	100-100+	39-100+	25-51

Notes:

1) Minimum coating thickness on samples that are not centrifuged.
2) Larger coating thicknesses can only be achieved when the steel has a specified silicon content.
3) Minimum local coating thickness according to EN ISO 1461:2022.
4) Mean coating thickness according to EN ISO 1461:2022.
5) In category C5 it may be necessary to use duplex (galvanizing + painting) to reach longer life times.

Table 4. The life in years for galvanized coatings used in corrosion categories C1 -C5. The lifetimes are based on minimum local coating thickness according to EN ISO 1461:2022.

Corrosion category	Coating thickness
C3	Fe/Zn according to EN ISO 1461:2022
C4	Fe/Zn 115 µm according to ”Steels suitable for galvanizing”
C5	Fe/Zn 215 µm according to ”Steels suitable for galvanizing” or Duplex (galvanizing + painting)

Table 5. Suitable corrosion protection for exposure in different corrosivity classes

More information is provided by:

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