Appendix: Corrosion Data for Zinc Exposed to Water

This appendix includes exposure test data used to obtain real-world corrosion rates for zinc coated steels (including hot-dip galvanized steel and continuous galvanized sheet) exposed to water environments. Results from accelerated laboratory tests sometimes use artificial solutions to simulate the effects of water exposure on galvanized steel, and such test results should be viewed skeptically. Real world corrosion rates for zinc and hot-dip galvanized articles often differ significantly from accelerated laboratory tests.

The available corrosion data covers a variety of locations, exposure periods, and water properties which may be used to roughly evaluate the performance of a hot-dip galvanized coating in a similar application. Any water type (freshwater, seawater, poolwater, etc.) can vary significantly in properties and corrosivity. Therefore, actual corrosion rates for zinc vary, and evaluation of corrosion rate data is for guidance only.

***Note:** For an explanation of the zinc types used for hot-dip galvanizing (noted in the data tables), please refer to AGA guidance on EN 1179 and ASTM B6 specifications for zinc grades.

Corrosion of Zinc-Coated Steel in Selected Natural Fresh Waters

Location and water	Type of zinc*	Years of Exposure	Agitation	Corrosion rate (µm/year)
Gatun Lake, Canal Zone Tropical freshwater	Intermediate	4	Stagnant	13
Gatun Lake, Canal Zone Tropical freshwater	Intermediate	8	Stagnant	10
Pedro Miguel locks, Panama Freshwater	Special high grade	5		18
Pedro Miguel locks, Panama Freshwater	High grade	5		13
Pedro Miguel locks, Panama Freshwater	Intermediate	5		11
Pedro Miguel locks, Panama Freshwater		5		14
Pedro Miguel locks, Panama Freshwater	Prime Western	5		13
Ampari River, Brazil Freshwater		0.4	2.8 ft/s flow	137
Ampari River, Brazil Freshwater		0.45	2.2 ft/s flow	198
Source: Porter, F. C.; Corrosion Resistance of Zinc and Zinc Alloys. Dekker, New York, 523pp. 1994.				

Corrosion of Zinc and Zinc-Coated Steel in Sea Water

Location and water	Type of zinc*	Type of test	Years of Exposure	Agitation	Corrosion rate (μm/year)
Eastport, Maine Seawater	99.1% zinc	Mean tide level	3		25
Eastport, Maine Seawater	99.1% zinc	Immersion	3		16
Bristol Channel Seawater	Prime Western	Immersion about 93% of time	4		91
Bristol Channel Seawater	Galvanized bar	Immersion about 93% of time	4		64
Southhampton docks Seawater	Prime western	At half-tide level	3		13
Southhampton docks Seawater	High grade	At half-tide level	3		14
Southhampton docks Seawater		Immersion	1		28
Fort Amador, Canal Zone Tropical, Pacific Ocean	Intermediate	Immersion	4	0.15 m/s flow	20
Fort Amador, Canal Zone Tropical, Pacific Ocean	Intermediate	Immersion	8	0.15 m/s flow	16
Fort Amador, Canal Zone Tropical, Pacific Ocean	Intermediate	Mean tide level	4	0.15 m/s flow	23
Fort Amador, Canal Zone Tropical, Pacific Ocean	Intermediate	Mean tide	8	0.15 m/s flow	14
Panama Seawater	Prime Western	Immersion	1		25
Panama Seawater	Special high-grade	Immersion	1		25
Kure Beach, North Carolina Seawater	Special high-grade	Immersion	0.5	Flowing	48
Kure Beach, North Carolina Seawater	Special high-grade	Immersion	4	Flowing	20
Kure Beach, North Carolina Seawater		Immersion	0.5	Flowing	48
Kure Beach, North Carolina Seawater		Immersion	1	Flowing	23

Location and water	Type of zinc*	Type of test	Years of Exposure	Agitation	Corrosion rate (µm/year)
Kure Beach, North Carolina Seawater		Immersion	3.5	Flowing	15
Kure Beach, North Carolina Seawater		Immersion	5	Flowing	13
Gosport & Emsworth Seawater	Hot-dipped	Immersion	6	Flowing	9
Gosport & Emsworth Seawater	Hot-dipped	Immersion	6	Flowing	9
Gosport & Emsworth Seawater	Cyanide, electrodeposit	Immersion	6	Flowing	8
Gosport & Emsworth Seawater	Sprayed, molten metal pistol	Immersion	6	Flowing	4
Gosport & Emsworth Seawater	Sprayed, powder pistol	Immersion	6	Flowing	17
Gosport & Emsworth Seawater	Sprayed, wire pistol	Immersion	6	Flowing	6
Pacific Ocean Seawater	99.9% Zinc	Immersion 5,640 ft	0.34	N/A	170
Pacific Ocean Seawater	99.9% Zinc	Immersion 6,780 ft	1	N/A	150
Pacific Ocean Seawater	99.9% Zinc	Immersion 5,640 ft	2	N/A	91
Pacific Ocean Seawater	99.9% Zinc	Immersion 1,064 ft	3	N/A	61
Pacific Ocean Seawater	99.9% Zinc	Immersion 2,340 ft	0.5	N/A	58
Pacific Ocean Seawater	99.9% Zinc	Immersion 2,370 ft	1	N/A	71
Pacific Ocean Seawater	99.9% Zinc	Immersion 5 ft	0.5	N/A	114
Pacific Ocean Seawater	99.9% Zinc	Immersion 5 ft	1	N/A	71

Source: Porter, F. C. Corrosion Resistance of Zinc and Zinc Alloys. Dekker, New York, 523pp. 1994.
Zhang, Xiaoge Gregory; Corrosion and Electrochemistry of Zinc, Plenum Press, New York. 1996.
Slunder, C. J., and Boyd, W. K.; Zinc: Its Corrosion Resistance, 2nd ed., International Lead Zinc Research Organization, Inc., New York, 1986.

Corrosion of Zinc Coatings Immersed in Various Industrial and Domestic Waters

Type of water	Temperature (C)	Corrosion Rate (µm/yr)
Mine water, pH 8.3, 100 ppm hardness, aerated, slight agitation	20	31
Mine water, 160 ppm hardness, aerated, slight agitation	20	30
Mine water, 110 ppm hardness, aerated, slight agitation	22	46
Demineralized water from anion and cation exchangers, 3gal/min/sqft agitation	18	137
Riverwater, untreated, mod. soft, 0.7ft/s agitation	Ambient	97
Aqueduct Riverwater, untreated, mod. soft, 0.7ft/s agitation	Ambient	61
River water, treated by chlorination and copper sulphate, 0.5ft/s agitation	Ambient	64
Tap water, pH 5.6, 170 ppm hardness, aerated, considerable agitation	5	142
Tap Water, 50ppm hardness	Room	18
Spray cooling water, chromate treated, aerated	15	15
Sources: Defrancq, J. N.; Zinc and zinc-lead alloys in domestic water, Br. Corros. J. 17, 125-130, 1982. Slunder, C. J., and Boyd, W. K.; Zinc: Its Corrosion Resistance, 2nd ed., International Lead Zinc Research Organization, Inc., New York, 1986.		

Corrosion of Zinc-Coated Steel in Distilled Waters

Test Condition	Temperature (C)	Corrosion rate (µm/year)
Boiled distilled water	Room	25.4
Boiled distilled water	40	48.3
Boiled distilled water	65	83.8
Oxygen bubbled slowly through the water	Room	218.4
Oxygen bubbled slowly through the water	40	348.0
Oxygen bubbled slowly through the water	65	315.0
Source: Zhang, Xiaoge Gregory; Corrosion and Electrochemistry of Zinc, Plenum Press, New York. 1996.		