

## Appendix C11 Corrosion in Chloric acid (HCl)

1. Corrosion rates of carbon steel and 300 series stainless steels with pH and temperature are shown in Table 1 and 2.

Table 1 Corrosion rate<sup>\*1</sup> of carbon steel in HCL (mm/year)

\*1 For local corrosion which is 10 times high than general corrosion

pH	Temperature (°C)			
	< 38	38 ~ 65	66 ~ 95	> 95
≤ 0.5	25.4	25.4	25.4	25.4
0.6 ~ 1.0	22.9	25.4	25.4	25.4
0.6 ~ 1.0	10.2	25.4	25.4	25.4
1.6 ~ 2.0	5.08	17.8	25.4	25.4
2.1 ~ 2.5	2.54	7.62	10.2	14.2
2.6 ~ 3.0	1.52	3.30	5.08	7.11
3.1 ~ 3.5	1.02	1.78	2.54	3.56
3.6 ~ 4.0	0.76	1.27	2.29	3.18
4.1 ~ 4.5	0.51	1.02	1.78	2.54
4.6 ~ 5.0	0.25	0.76	1.27	1.78
5.1 ~ 5.5	0.18	0.51	0.76	1.02
5.6 ~ 6.0	0.10	0.38	0.51	0.76
6.1 ~ 6.5	0.08	0.25	0.38	0.51
6.6 ~ 7.0	0.05	0.13	0.18	0.25

Table 2 Corrosion rate<sup>\*1</sup> of 300 series stainless steel in HCL (mm/year)

\*1 For local corrosion which is 10 times high than general corrosion

pH	Temperature (°C)			
	< 38	38 ~ 65	66 ~ 95	> 95
≤ 0.5	22.9	25.4	25.4	25.4
0.6 ~ 1.0	12.7	25.4	25.4	25.4
0.6 ~ 1.0	7.62	12.7	17.8	25.4
1.6 ~ 2.0	3.81	6.60	10.2	12.7
2.1 ~ 2.5	2.03	3.56	5.08	6.35
2.6 ~ 3.0	1.27	1.78	2.54	3.05
3.1 ~ 3.5	0.76	1.02	1.27	1.65
3.6 ~ 4.0	0.51	0.64	0.76	0.89
4.1 ~ 4.5	0.25	0.38	0.51	0.64
4.6 ~ 5.0	0.13	0.18	0.25	0.30
5.1 ~ 5.5	0.10	0.13	0.15	0.18

5.6 ~ 6.0	0.08	0.10	0.13	0.15
6.1 ~ 6.5	0.05	0.08	0.10	0.13
6.6 ~ 7.0	0.03	0.05	0.05	0.10

2. Corrosion rates of various alloys with Cl<sup>-</sup> content and temperature are shown in Table 3 and 4.

Table 3 Corrosion rate of Alloy825, Alloy20, Alloy625, AlloyC-276 in HCL (mm/year)

Alloy	Cl <sup>-</sup> content (Weight%)	Temperature (°C)			
		< 38	38 ~ 65	66 ~ 95	> 95
Alloy 825 Alloy 20	≤ 0.5	0.03	0.08	1.02	5.08
	0.5 ~ 1	0.05	0.13	2.03	10.2
	>1 ~ 5	0.25	1.78	7.62	25.4
Alloy 625	≤ 0.5	0.03	0.05	0.38	1.91
	0.5 ~ 1	0.03	0.13	0.64	3.18
	>1 ~ 5	0.05	1.78	5.08	10.2
Alloy C-276	≤ 0.5	0.03	0.05	0.20	0.76
	0.5 ~ 1	0.03	0.05	0.38	1.91
	>1 ~ 5	0.05	0.25	1.52	7.62

Table 4 Corrosion rate of AlloyB-2, Alloy400 in HCL (mm/year)

Alloy	Cl <sup>-</sup> content (Weight%)	Temperature (°C)							
		< 38		38 ~ 65		66 ~ 95		> 95	
		Yes/No for dissolved oxygen and oxidizing agents							
		No	Yes	No	Yes	No	Yes	No	Yes
Alloy B-2	≤ 0.5	0.03	0.10	0.03	0.10	0.05	0.20	0.10	0.38
	0.5 ~ 1	0.03	0.10	0.03	0.10	0.13	0.51	0.51	2.03
	>1 ~ 5	0.05	0.20	0.13	0.51	0.25	1.02	0.64	2.54
Alloy 400	≤ 0.5	0.03	0.10	0.08	0.30	0.76	3.05	7.62	25.4
	0.5 ~ 1	0.05	0.25	0.13	0.51	2.03	8.13	20.3	25.4
	>1 ~ 5	0.51	1.02	0.64	2.54	3.81	15.2	22.9	25.4

3. Table 5 can be used to know the relation between Cl<sup>-</sup> content (Weight%) and pH

Table 5 Relation between Cl<sup>-</sup> content (Weight%) and pH

Cl <sup>-</sup> content (Weight ppm)	pH
3,601 ~ 12,000	0.5
1,201 ~ 3,600	1.0
361 ~ 1,200	1.5
121 ~ 360	2.0

36 ~ 120	2.5
16 ~ 35	3.0
6 ~ 15	3.5
3 ~ 5	4.0
1 ~ 2	4.5
< 1	5.0

Note) Assuming no alkaline substances exist (NH<sub>3</sub>, neutralized amines, neutralized alkali, etc.)

#### Reference

1. Metal Handbook, Vol.13, "Corrosion", ASM International.
2. T.S.Lee, III, and F.G. Hodge, Resistance of Hastelloy Alloys to Corrosion by Inorganic Acids, Materials Performance, September 1976, pp.29.
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4. Resistance to Corrosion, Inco Alloys International, Inc.
5. "Resistance of Nickel and High Nickel Alloys to Corrosion by Hydrochloric Acid, Hydrogen Chloride and Chlorine", Corrosion Engineering Bulletin CEB-3, The International Nickel Company, Inc., 1969.
6. L. Colombier and J. Hochmann, Stainless and Heat Resisting Steels, St. Martins Press, New York, NY.

