Corrosion Data

Table 1. ELECTROCHEMICAL EQUIVALENTS

Electrode Reaction	*Electrochemical Equivalent** *(grams/coulomb)*
$K=K^++e^-$	4.0513×10^{-4}
$Ca=Ca^{++}+2e^-$	2.0767×10^{-4}
$Na=Na^++e^-$	2.3830×10^{-4}
$Mg=Mg^{++}+2e^-$	1.2600×10^{-4}
$Al=Al^{+++}+3e^-$	0.9316×10^{-4}
$M=Mn^{++}+2e^-$	2.8461×10^{-4}
$Zn=Zn^{++}+2e^-$	3.3875×10^{-4}
$Cr=Cr^{+++}+3e^-$	1.7965×10^{-4}
$Fe=Fe^{++}+2e^-$	2.8938×10^{-4}
$Cd=Cd^{++}+2e^-$	5.8243×10^{-4}
$Co=Co^{++}+2e^-$	3.0539×10^{-4}
$Ni=Ni^{++}+2e^-$	3.0409×10^{-4}
$Sn=Sn^{++}+2e^-$	6.1502×10^{-4}
$Pb=Pb^{++}+2e^-$	10.736×10^{-4}
$Fe=Fe^{+++}+3e^-$	1.9292×10^{-4}
$H_2=2H^++2e^-$	0.1045×10^{-4}
$Cu=Cu^{++}+2e^-$	3.2937×10^{-4}
$Cu=Cu^++e^-$	6.5875×10^{-4}
$2Hg=Hg_2^{++}+2e^-$	20.788×10^{-4}
$Ag=Ag^++e^-$	11.180×10^{-4}
$Hg=Hg^{++}+2e^-$	10.394×10^{-4}
$Pt=Pt^{++}+2e^-$	10.115×10^{-4}
$Au=Au^{+++}+3e^-$	6.8117×10^{-4}
$Au=Au^++e^-$	20.435×10^{-4}
$2I^-=I_2+2e^-$	13.150×10^{-4}
$2Br^-=Br_2(l)+2e^-$	8.2814×10^{-4}
$Cl^-=\frac{1}{2}Cl_2+e^-$	3.6743×10^{-4}
$^-=F_2+2e^-$	1.9689×10^{-4}
$S^{--}=S+2e^-$	1.6611×10^{-4}

*These values are based on the International Atomic Weights for 1941 and the value of 96,501 international coulombs per gram-equivalent for Faraday's constant.

Table 2. ELECTROMOTIVE FORCE SERIES*

Electrode Reaction	*Standard Electrode Potential, E^0(volts), 25°C*
$K=K^++e^-$	−2.922
$Ca=Ca^{++}+2e^-$	−2.87
$Na=Na^++e^-$	−2.712
$Mg=Mg^{++}+2e^-$	−2.34
$Be=Be^{++}+2e^-$	−1.70
$Al=Al^{+++}+3e^-$	−1.67
$Mn=Mn^{++}+2e^-$	−1.05
$Zn=Zn^{++}+2e^-$	−0.762
$Cr=Cr^{+++}+3e^-$	−0.71
$Ga=Ga^{+++}+3e^-$	−0.52
$Fe=Fe^{++}+2e^-$	−0.440
$Cd=Cd^{++}+2e^-$	−0.402
$In=In^{+++}+3e^-$	−0.340
$Tl=Tl^++e^-$	−0.336
$Co=Co^{++}+2e^-$	−0.277
$Ni=Ni^{++}+2e^-$	−0.250
$Sn=Sn^{++}+2e^-$	−0.136
$Pb=Pb^{++}+2e^-$	−0.126
$H_2=2H^++2e^-$	0.000
$Cu=Cu^{++}+2e^-$	0.345
$Cu=Cu^++e^-$	0.522
$2Hg=Hg_2^{++}+2e^-$	0.799
$Ag=Ag^++e^-$	0.800
$Pd=Pd^{++}+2e^-$	0.83
$Hg=Hg^{++}+2e^-$	0.854
$Pt=Pt^{+++}+2e^-$	ca 1.2
$Au=Au^{+++}+3e^-$	1.42
$A=Au^++e^-$	1.68

*Signs of potential employed by the AmericanChem. Soc. are opposite to those of this table.

Table 3. STANDARD OXIDATION-REDUCTION POTENTIALS AT 25°C*, †, ‡

Couple	E^0
$Cr^{++}=Cr^{+++}+e^-$	−0.41
$Pb+SO_4^{--}=PbSO_4+2e^-$	−0.355
$Pb+2Cl^-=PbCl_2+2e^-$	−0.268
$Cl^-+Cu=CuCl+e^-$	0.124
$H_2S=S+2H^++2e^-$	0.141
$Sn^{++}=Sn^{++++}+2e^-$	0.15
$Cu^+=Cu^{++}+e^-$	0.167
$Ag+Cl^-=AgCl+e^-$	0.222
$2Hg+2Cl^-=Hg_2Cl_2+2e^-$	0.268
$Fe(CN)_6^{----}=Fe(CN)_6^{---}+e^-$	0.36
$2I^-=I_2+2e$	0.535

Couple	E^0
$2Hg+SO_4^{--}=Hg_2SO_4+2e^-$	0.615
$H_2O_2=O_2+2H^++2e^-$	0.682
$Fe^{++}=Fe^{+++}+e^-$	0.771
$2H_2O=O_2+4H^+(10^{-7}M)+4e^-$	0.815
$Hg_2^{++}=2Hg^{++}+2e^-$	0.910
$HNO_2+H_2O=NO_3^-+3H^++2e^-$	0.94
$NO+H_2O=HNO_2+H^++e^-$	0.99
$2Br^-=Br_2(l)+2e^-$	1.065
$2H_2O=O_2+4H^++4e^-$	1.229
$Tl^+=Tl^{+++}+2e^-$	1.25
$Mn^{++}+2H_2O=MnO_2+4H^++2e^-$	1.28
$Au^+=Au^{+++}+2e^-$	ca 1.29
$Cl^-=\frac{1}{2}Cl_2+e^-$	1.358
$2Cr^{+++}+7H_2O=Cr_2O_7^{--}+14H^++6e^-$	1.36
$Pb^{++}+2H_2O=PbO_2+4H^++2e^-$	1.456
$Cl^-+H_2O=HClO+H^++2e^-$	1.49
$Mn^{++}=Mn^{+++}+e^-$	1.51
$Mn^{++}+4H_2O=MnO_4^-+8H^++5e^-$	1.52
$Ce^{+++}=Ce^{++++}+e^-$	1.61
$\frac{1}{2}Cl_2+H_2O=H^++HClO+e^-$	1.63
$MnO_2+2H_2O=MnO_4^-+4H^++3e^-$	1.67
$PbSO_4+2H_2O=PbO_2+SO_4^{--}+4H^++2e^-$	1.685
$Pb^{++}=Pb^{++++}+2e^-$	1.69
$Ni^{++}+2H_2O=NiO_2+4H^++2e^-$	1.75
$2H_2O=H_2O_2+2H^++2e^-$	1.77
$Co^{++}=Co^{+++}+e^-$	1.84
$Ag^+=Ag^{++}+e^-$	1.98
$2SO_4^{--}=S_2O_8^{--}+2e^-$	2.05
$O_2+H_2O=O_3+2H^++2e^-$	2.07
$H_2O=O(g)+2H^++2e^-$	2.42
$2F^-=F_2+2e^-$	2.85
$Mg+2OH^-=Mg(OH)_2+2e^-$	−2.67
$Al+4OH^-=H_2AlO_3^-+H_2O+3e^-$	−2.35
$Al+3OH^-=Al(OH)_3+3e^-$	−2.31
$Mn+2OH^-=Mn(OH)_2+2e^-$	−1.47
$Zn+S^{--}=ZnS+2e$	−1.44
$Mn+CO^{--}=Mn_3CO_3+2e^-$	−1.35
$Cr+3OH^-=Cr(OH)_3+3e^-$	−1.3
$Zn+2OH^-=Zn(OH)_2+2e^-$	−1.245
$Cd+S^{--}=CdS+2e^-$	−1.23
$Zn+4OH^-=ZnO_2^{--}+2H_2O+2e^-$	−1.216
$Cr+4OH^-=CrO_2^-+2H_2O+3e^-$	−1.2
$Ni+S^{--}=NiS(\gamma)+2e^-$	−1.07

Couple	E^0
$Zn+CO_3^{--}=ZnCO_3+2e^-$	−1.07
$Fe+S^{--}=FeS+2e^-$	−1.00
$Pb+S^{--}=PbS+2e^-$	−0.98
$2Cu+S^{--}=Cu_2S+2e^-$	−0.95
$Co+S^{--}=CoS(\alpha)+2e^-$	−0.93
$Fe+8OH^-=Fe_3O_4+4H_2O+8e^-$	−0.91
$Fe+2OH^-=Fe(OH)_2+2e^-$	−0.877
$Ni+S^{--}=NiS(\alpha)+2e^-$	−0.86
$H_2+2OH^-=2H_2O+2e^-$	−0.828
$Cd+2OH^-=Cd(OH)_2+2e^-$	−0.815
$Cd+CO_3^{--}=CdCO_3+2e^-$	−0.80
$Sn+3OH^-=HSnO_2^-+H_2O+2e^-$	−0.79
$Cu+S^{--}=CuS+2e^-$	−0.76
$Fe+CO_3^{--}=FeCO_3+2e^-$	−0.755
$Co+2OH^-=Co(OH)_2+2e^-$	−0.73
$Fe+3OH^-=Fe(OH)_3+3e^-$	ca −0.73
$2Ag+S^{--}=Ag_2S+2e^-$	−0.71
$Hg+S^{--}=HgS+2e^-$	−0.70
$Ni+2OH^-=Ni(OH)_2+2e^-$	−0.68
$Co+CO_3^{--}=CoCO_3+2e^-$	−0.632
$S^{--}+6OH^-=SO_3^{--}+3H_2O+6e^-$	−0.61
$Pb+2OH^-=PbO(r)+H_2O+2e$	−0.578
$Fe(OH)_2+OH^-=Fe(OH)_3+e^-$	−0.56
$Pb+3OH^-=HPbO_2^-+H_2O+2e^-$	−0.54
$Pb+CO_3^{--}=PbCO_3+2e^-$	−0.506
$Ni+CO_3^{--}=NiCO_3+2e^-$	−0.45
$Mn(OH)_2+OH^-=Mn(OH)_3+e^-$	−0.40
$2Cu+2OH^-=Cu_2O+H_2O+2e^-$	−0.361
$2CN^-+Ag=Ag(CN)_2^-+e^-$	−0.29
$Cu+2OH^-=Cu(OH)_2+2e^-$	−0.224
$Cr(OH)_3+5OH^-=CrO_4^{--}+4H_2O+3e^-$	−0.12
$OH+HO_2=O_2+H_2O+2e^-$	−0.076
$4NH_3+Cu=Cu(NH_3)_4^{++}+2e^-$	−0.05
$Cu+CO_3^{--}=CuCO_3+2e^-$	0.053
$Hg+2OH^-=HgO(r)+H_2O+2e^-$	0.098
$2Hg+2OH^-=Hg_2O+H_2O+2e^-$	0.123
$2Hg+CO_3^{--}=Hg_2CO_3+2e^-$	0.32
$2Ag+2OH^-=Ag_2O+H_2O+2e^-$	0.344
$2NH_3(Aq)+Ag=Ag(NH_3)_2^++e^-$	0.373
$4OH^-=O_2+2H_2O+4e^-$	0.401
$2Ag+CrO_4^{--}=Ag_2CrO_4+2e^-$	0.446
$2Ag+CO_3^{--}=Ag_2CO_3+2e^-$	0.47

Couple	E^0
$Ni(OH)_2+2OH^-=NiO_2+2H_2O+2e^-$	0.49
$MnO_4^{--}=MnO_4^-+e^-$	0.54
$MnO_2+4OH^-=MnO_4^-+2H_2O+3e^-$	0.57
$Cl^-+2OH^-=ClO^-+H_2O+2e^-$	0.94
$O_2+2OH^-=O_3+H_2O+2e^-$	1.24

* W. M. Latimer, *Oxidation Potentials*, Prentice-Hall, Inc., New York, 1938. Notethat the American Chemical Society uses a convention of sign opposite to that employed here. †For metal electrode potentials, refer also to **Table 2**.

‡ Signs of potential employed by the American Chem. Soc. are opposite to those of this table.

Table 4. STANDARD REFERENCE ELECTRODES

$$E=E_{25}{}^\circ+\frac{dE}{dt}t$$

Name	Cell	$E_{25}{}^\circ$ (volts)	$E_{25}{}^\circ$ (strong acids)	$E_{25}{}^\circ$ (buffers)	$\frac{dE}{dt}$ (volts/deg. C)
0.1 *N* calomel	$Hg/Hg_2Cl_2/KCl$ (0.1 *N*)	0.3337*	0.3386†	0.336 †	-0.7×10^{-4}
1.0 *N* calomel	$Hg/Hg_2Cl_2/KCl$ (1.0 *N*)	0.2800*	0.2848†	0.2828†	-2.4×10^{-4}
Saturated calomel‡	$Hg/Hg_2Cl_2/KCl$ (saturated)	0.2415*	0.2457†	0.2434†	-7.6×10^{-4}
Silver chloride	$Ag/AgCl/KCl$ (0.1 *N*)	0.2881*	...	...	-6.5×10^{-4}
Copper sulfate ‡§	$Cu/CuSO_4/CuSO_4$ (sat'd)	0.316	...	...	9.0×10^{-4}

* The *E* values so marked are true values in that they do not include liquid junction potentials.

† The *E* values so marked include an approximate value for the liquid junction potentials. See W. J. Hamer, *Trans. Electrochem. Soc.*, 72, 62(1937).

‡ The *E* of this electrode is subject to pronouned hysteresis effects and should be used only at constant temperature.

§ S. Ewing, *The Copper-Copper Sulfate Half Cell for Measuring Potentialt in the Earth*, p. 10, Committee Report, American Gas Association, 1939.

Table 5. SOLUBILITY PRODUCT CONSTANTS AT 25°C

Reaction	Solubility Product
$Al(OH)_3=Al^{+++}+3OH^-$	1.9×10^{-33}
$Al(OH)_3=H^++H_2AlO_3^-$	4×10^{-13}
$Cd(OH)_2=Cd^{++}+2OH^-$	1.2×10^{-14}
$CdS=Cd^{++}+S^{--}$	1.4×10^{-28}
$CdCO_3=Cd^{++}+CO_3^{--}$	2.5×10^{-14}
$Ca(OH)_2=Ca^{++}+2OH^-$	7.9×10^{-6}
$CaCO_3=Ca^{++}+CO_3^{--}$	4.82×10^{-9}*
$CaSO_4\cdot2H_2O=Ca^{++}+SO_4^{--}+2H_2O$	2.4×10^{-5}
$Ca_3(PO_4)_2=3Ca^{++}+2PO_4^{---}$	1×10^{-25}
$CaHPO_4=Ca^{++}+HPO_4^{--}$	ca 5×10^{-6}
$Cr(OH)_3=Cr^{+++}+3OH^-$	6.7×10^{-31}
$Cr(OH)_3=H^++CrO_2^-+H_2O$	9×10^{-17}
$Co(OH)_2=Co^{++}+2OH^-$	2×10^{-16}
$CoCO_3=Co^{++}+CO_3^{--}$	1.0×10^{-12}
$^1/_2Cu_2O+{}^1/_2H_2O=Cu^++OH^-$	1.2×10^{-15}
$Cu_2S=2Cu+S^{--}$	2.5×10^{-50}
$Cu(OH)_2=Cu^{++}+2OH^-$	5.6×10^{-20}
$CuS=Cu^{++}+S^{--}$	4×10^{-38}
$CuCO_3=Cu^{++}+CO_3^{--}$	1.37×10^{-10}
$Fe(OH)_2=Fe^{++}+2OH^-$	1.65×10^{-15}
$FeCO_3=Fe^{++}+CO_2^{--}$	2.11×10^{-11}
$FeS=Fe^{++}+S^{--}$	1×10^{-19}
$Fe(OH)_3=Fe^{+++}+3OH^-$	4×10^{-38}
$Pb(OH)_2=Pb^{++}+2OH^-$	2.8×10^{-16}
$PbO(r)+H_2O=Pb^{++}+2OH^-$	5.5×10^{-16}
$Pb(OH)_2=H^++HPbO_2^-$	2.1×10^{-16}
$PbO(y)+OH^-=HPbO_2^-$	5.31×10^{-5}
$PbO(r)+OH^-=HPbO_2^-$	4.03×10^{-2}
$PbCl_2=Pb^{++}+2Cl^-$	1.7×10^{-5}
$PbCO_3=Pb^{++}+CO_3^{--}$	1.5×10^{-13}
$PbS=Pb^{++}+S^{--}$	1.0×10^{-29}
$PbCrO_4=Pb^{++}+CrO_4^{--}$	1.8×10^{-14}
$PbSO_4=Pb^{++}+SO_4^{--}$	1.8×10^{-8}
$PbO_2+2H_2O=Pb^{++}+4OH^-$	10^{-64}
$Mg(OH)_2=Mg^{++}+2OH^-$	5.5×10^{-12}*
$MgCO_3\cdot3H_2O=Mg^{++}+CO_2^{--}+3H_2O$	ca 1×10^{-5}*
$Mn(OH)_2=Mn^{++}+2OH^-$	7.1×10^{-15}
$MnCO_3=MnCO_3=Mn^{++}+CO_3^{--}$	8.8×10^{-11}
$MnS=Mn^{++}+S^{--}$	5.6×10^{-16}
$Hg_2O+H_2O=Hg_2^{++}+2OH^-$	1.6×10^{-23}
$Hg_2Cl_2=Hg_2^{++}+2Cl^-$	1.1×10^{-18}
$Hg_2CO_3=Hg_2^{++}+CO_3^{--}$	9×10^{-17}

Reaction	*Solubility Product*
$Hg_2SO_4 = Hg_2^{++} + SO_4^{--}$	6.2×10^{-7}
$Hg_2S = Hg_2^{++} + S^{--}$	1×10^{-45}
$HgO + H_2O = Hg^{++} + 2OH^-$	1.7×10^{-26}
$HgS = Hg^{++} + S^{--}$	3×10^{-53}
$Ni(OH)_2 = Ni^{++} + 2OH^-$	1.6×10^{-14}
$NiCO_3 = Ni^{++} + CO_3^{---}$	1.36×10^{-7}
$NiS(\alpha) = Ni^{++} + S^{--}$	3×10^{-21}
$NiS(\beta) = Ni^{++} + S^{--}$	1×10^{-26}
$NiS(\gamma) = Ni^{++} + S^{--}$	2×10^{-26}
$Pt(OH)_2 = Pt^{++} + 2OH^-$	ca 1×10^{-35}
$^1/_2 Ag_2O + ^1/_2 H_2O = Ag^+ + OH^-$	2.0×10^{-8}
$AgCl = Ag^+ + Cl^-$	1.7×10^{-10}
$Ag_2S = 2Ag^+ + S^{--}$	1.0×10^{-51}
$Ag_2CO_3 = 2Ag^+ + CO_3^{--}$	8.2×10^{-12}
$Ag_2SO_4 = 2Ag^+ + SO_4^{--}$	1.18×10^{-5}
$Sn(OH)_2 = Sn^{++} + 2OH^-$	5×10^{-26}
$H_2SnO_2 = H^+ + HSnO_2^-$	6×10^{-18}
$SnS = Sn^{++} + S^{--}$	8×10^{-29}
$Sn(OH)_4 = Sn^{++++} + 4OH^-$	ca 1×10^{-56}
$Sn(OH)_4 + 2OH^- = Sn(OH)_6^{--}$	2.1×10^{-4}
$Zn(OH)_2 = Zn^{++} + 2OH^-$	4.5×10^{-17}
$ZnCO_3 = Zn^{++} + CO_3^{--}$	6×10^{-11}
$ZnS = Zn^{++} + S^{--}$	4.5×10^{-24}

Table 6 Corrosive effects of some organic materials

Material	Corrosive fraction	Note	Corrosive effect†
Phenolic resins	Formaldehyde, ammonia	Mainly in form of glues and mouldings	3
Amino plastics	Formaldehyde, ammonia, formic acid, acid catalysts	Mainly adhesives, porous materials	2-3
Polyformaldehyde	Formaldehyde	Only when in contact	0-1
Polyvinyl chloride	Hydrogen chloride, some plasticisers	After breakdown by heat or radiation	1
Polyvinyl acetate	Acetic acid	In conditions supporting hydrolysis	1
Cellulose acetate	Acetic acid	In conditions supporting hydrolysis	1-2
Epoxides	Hydrogen chloride, ammonia, catalysts, setting agents	Dangerous mainly in curing stage	2
Polyesters	Maleic acid	Mainly when in con'tact	1
Hypalon	Sulphur dioxide		0-1
Teflon, Teflex	Hydrogen chloride, hydrogen fluoride, chlorinated and fluorinated compounds	Combined corrosion and operation stress (bearings)	0-1
Rubbers	Sulphur compounds	Affect copper, silver, cadmium, nickel	1-2
Polystyrene	Styrene	Combined corrosion and operation stress	1-2
Oil and alkyd materials	Aliphatic acids	Putties, coatings	0-1
Polyamide alkali	Alkaline fractions	Aluminum in contact	1
Woods*	Acetic acid, formic acid	Mainly in humid hot environment	0-3*
Plywoods	Acetic acid, formic acid, formaldehyde	Mainly in humid hot environment	2-3

† 0 no effect; 1 slightly corrosive; 2 corrosive; 3 highly corrosive

* Deleterious effects depend very much on the kind of wood: oak and beech are strong corrosives but spruce, walnut and fir are almost without effect (see **Tables 8 and 10**)

Table 7. Composition and temperature fo pickling solutions

Metal	Composition of solution		Temperature, °C
Low-carbon steel	HCl (d=1·17)	1000ml	20±5
	$SnCl_2$	50g	
	Sb_2O_3	20g	
Zinc	CH_3COOH (glacial)	50ml	20-40
	Distilled water	up to 1000ml	
Copper and brass	H_2SO_4 (d=1·84)	50ml	20-40
	Distilled water	up to 1000ml	
Aluminium	H_3PO_4, 65%	35ml	98-100
	CrO_3	20g	
	Distilled wnter	up to 1000ml	
Cadmium	NaCN, 5% solution		20-40

Table 8. Corrosive effects of organic high molecular-weight materials in (i) sealed enclosures or (ii) by contact

Material	Degree of corrosive effect on metal									
	Fe		Zn		Cu		Al		Cd	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
Phenolic resins[a]	2	3	5	3	3	3	1	2	2	3
Amino plastics[a]	1	2	2	3	2	2	1	2	1	2
Polyformaldehyde	0	1	1	1	0	0	0	0	0	1
Polycarbonates	0	1	0	1	0	0	0	0	0	0
Polyvinyl chloride[b]	0-1	1	0-1	1	0	0	0	0	0	0
Polyamide alkali	0	0	0	1	0	1	1	2	1	2
Polyamide hydro	0	0	0	0	0	0	0	1	0	0
Glass-reinforced polyesters	1	1	2	2	0	1	0	0	1	1
Epoxides	1	1	2	2	1	1	0	0	1	1
Polyethylene	0	0	0	0	0	0	0	0	0	0
Polymethyl methacrylate	0	0	0	0	0	0	0	0	0	0
Polystyrene[d]	0	0	0	0	0	0	0	0	0	0
Polyvinyl acetate	1	1	1	1	0	0	0	0	0	1
Teflon	0	1	0	1	—	—	—	—	—	—
Teflex	0	1	0	1	—	—	—	—	—	—
Cellulose acetate	1	1-2	1-2	1-2	0	0	0	0	1	1
Rubbers[c]	0	1	0	1	1	1	0	0	1	2
Paints oil	0	1	0	1	0	0	0	0	0	0
Epoxide[c]	1	1	2	2	0	0	0	1	0	1
Melamine alkyd[c]	1	1	1	1	0	0	0	0	0	0
Woods:										
Oak	3	3	3	3	2	2	1	1	2	2
Beech	3	3	3	3	2	2	1	1	2	2
Chestnut	2	2	2	2	1	2	0	0	1	1
Birch	1-2	1-2	2	2	1	1	0	0	1	1
Fir	0-1	0-1	1-2	1-2	1	1	0	0	1	1
Walnut	0	0	0	0	0	0	0	0	0	0
Elm	0	0	0	0	0	0	0	0	0	0

Corrosive effect: 0, none; 1, slightly corrosive; 2, corrosive; 3, highly corrosive

[a] There are differences in the corrosive effect between individual phenolic resins and amino plastics.

[b] The corrosive effect of some plasticised PVC materials and especially of paint was noticed after preliminary irradiation by u. v. -or ν-radiation

[c] The corrosive effect is most intense during the curing period.

[d] Styrene after adsorption and eventual pyrolysis causes depreciation of contact surfaces.

[e] With packing materials, in addition to the effect of adhesives, the influence of binders or intermediate layers should be taken into consideration.

Table 9. Aggressive ions present in corrosion products found on zinc

Test conditions	Amount of aggressive ion found on zinc, %			
	NH_4^+	Cl^-	CH_3COO^-	$HCOO^-$
Corrosion in sealed enclsureo at 100% R.H., 35°C, with metal and phenolic resin 30 mm apart	0.02	0.013	0.015	0.015
As above, but 5 mm apart	0.05	0.015	0.55	1.1
Corrosion when in contact, 100% R.H., 35°C	0.23	0.015	0.29	0.60
Corrosion when in contact with passage of d.c. current, 98% R.H., 30°C	0.50	6.0	0.30	0.80

Table 10. Losses of metal by corrosion stimulated by rubber (i) in sealed cnclosures and (ii) by direct contact

Rubber	Corrosion loss of metal, μm						
	Fe		Cu		Zn		Al
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)
Natural rubber, uncoloured	0.07	0.05	0.04	0.09	0.43	0.07	0.05
Natural rubber, carbon black	0.14	0.16	0.08	1.38	0.28	0.06	0.06
Butadiene/styrene mixture, uncoloured	0.13	0.05	0.06	0.65	0.31	0.07	0.10
Butadiene/styrene mixture, carbon black	0.11	0.08	0.15	2.50	0.19	0.08	0.06
Chloroprene mixture, uncoloured	0.08	0.02	0.10	0.08	0.21	0.05	0.08
Chloroprene mixture, carbon black	0.06	0.13	0.02	0.05	0.36	0.05	0.11
Isobutylene/isoprene mixture, uncoloured	0.10	0.07	0.12	0.37	0.24	0.06	0.10
Isobutylene/isoprene mixture, carbon black	0.30	0.05	0.20	0.78	0.20	0.04	0.04
Ethylene/propylene mixture, light	0.04	0.62	0.06	0.14	0.18	0.09	0.04
Ethylene/propylene mixture, carbon black	0.07	0.14	0.04	0.20	0.38	0.06	0.07

Table 11. Corrosivity of various organic materials

Material	Treatment	Sevrity of corrosion	Volatiles identified
1. *Woods*			
(a) oak and sweet-chestnut(and certain other woods especially certain Austrlian and tropical woods) containing free acetic acid in the natural state	air-drying at ambient temperat ures(natural seasoning)	very corrosive	actic acid
(b) other than (a) above	air-drying at ambient temperat-ures(natural seasoning)	non-corrosiveto slightly corrosive (may become more corrosive on exposure to hot e. g. tropical wet conditions)	
(c) all woods	kiln dried, steam treated, force dried after aqueous impregnation (rot-and fire-proofed), hot bon-ded	moderately to very corrosive	acetic acid, formic acid and traces of higher acids
2. *Plastics*			
(a) nylon, polystyrene, polyet-hylene, polypropylene, poly-carbonates, epoxides, PVC (at ambient temperatures), polyurethanes, formaldehyde condensation polymers	correctly formulated(fully cured, where appropriate) containing only 'inert' fillers(wood-flour fillers and undercured formalde-hyde condensation polymers may be very corrosive)	non-corrosive	
(b) polyesters	cured at ambient conditions with peroxide catalysts	moderately to very corrosive	fomic acid, usually acetic acid sometimes traces of higher acid

Material	Treatment	Severity of corrosion	Volatiles indentfied
(c) polyesters	cured with non-oxidising catalysts e. g. gamma radiation	non-corrosive	
(d) polyesters	hot curing	non-corrosive to moderately corrosive	mainly formic acid
(e) polyvinyl acetate	wihout additives	moderately to very corrosive	acetic acid
e Polyvinyl acetate	with stabilisers and inhibitors	non-corrosive	
(g) polyformaldehyde(acetate groups as end stoppers')		slightly corrosive at ambient temperature conditions. moderately corrosive at higher temperatures (>40°C)	formic acid
(h) polyformaldehyde(co-polymerised with 10% ethylene oxide)		non-corrosive at ambient temperate temperatures. slightly corrosive at higher temperatures (>45°C)	formic acid
3. *Rubbers*			
(a) non-vulcanised		slightly corrosive on prolonged exposure(some have been shown to oxidise on exposure)	formic acid and acetic acid
(b) vulcanised		slightly corrosive	hydrogen sulphide and sulphur dioxide
(c) synthetic	fully cured	non-corrosive	
(d) polysulphide rubber	cured with added peroxide catalysts (e. g. PbO_2) at ambient temperatures	moderately corrosive	formic acid
(e) siliconc rubbers with solvent, as sealants		non-corrosive to very corrosive (the solvent is frequently free acetic acid much of which may be retained)	acetic acid, esters
4. *Paints and Lacquers*			
(a) oleo-resinous type			
(i) air-drying(inert pigments)	freshly applied i. e. up to 10 days after application	moderately to very corrosive	formic acid, and other low molecular weight carboxylic acids and aldehydes
(ii) air-drying(inert pigments)	after 19 days or more(up to at least 18 months) air-drying	slightly to moderately corrosive	formic acid
(iii) air-drying, containing certain neutralising pigments e. g. zinc oxide, calcium plumate		non-corrosive under most conditions	
(iv) stoving paints		slightly to moderately corrosive	formic acid, traces of other acids
(b) air-drying solvent paints			
(i) chlorinated rubber in hydrocarbon solvent		normally non-corrosive but may become corrosive after exposure to ultra-violet radiation or prolonged storage at elevated temperatures	hydrogen chloride
(ii) cyclised rubber in hydrocarbon solvent		non-corrosive	
(iii) emulsion. based on polyvinyl acetate		non-corrosive to moderately	acetic acid
(iv) nisrocellulose	solvent fully removed(typically after 2 weeks)	corrosive	
(v) shellac		non-corrosive	
(vi) acrylics, solvent based	solvent fully removed(with thick films and certain solvents this may be up to 2 months)	non-corrosive	
(vii) two-pack epoxides and polyurethanes	solvent fully removed(typically after 2 weeks)	non-corrosive	
(c) synthetic stoving paints (epoxides. formaldehyde condensation polymers)	fully cured	non-corrosive	

Material	Treatment	Severity of corrosion	Volatiles identifidd
5. *Adhesives*			
(i) animal, vegetable and natural resin glues(e. g. casein, starch, shellac)		non-corrosive	
(ii) elastomeric in hydorocarbn solvent		non-corrosive to slightly corrosive	formic acid, acetic acid
(iii) elastomeric, containing ester solvents		moderately corrosive	acetic acid, esters
(iv) based on formaldehyde condensation polymers	fully cured	non-corrosive to very corrosive (cold cured resins are frequently catalysed by volatile acids; during curing, acidvolatiles evolved are frequently absorbed by the materials bonded)	formic acid and other volatiles
(v) based on epoxides		non-corrosive	
6. *Fabrics*			
(i) untreated		non-corrosive	
(ii) rot-proofed or moth-proofed		non-corrosive to moderately corrosive(these treatments are frequently preceded by a conditioning rinse in formic acid or acetic acid solution)	formic acid, acetic acid

Table. 12. Corrosion of metals by acetic and formic acid vapours at 30°C and 100% r. h. for 3 weeks

		Corrosion in air space, g/dm^3						
		Above acetic acid solution			Above formic acid solution			Control (no acid)
		0. 01 vol-% (0. 5ppm)	0. 10 vol-% (5ppm)	1. 0 vol-% (50ppm)	0. 01 vol-% (0. 6ppm)	0. 10 vol-% (6ppm)	1. 0 vol-% (60ppm)	
Mg	99. 9%	0. 38	2. 25	5. 70	0. 08	0. 08	0. 31	0. 10
Al	99. 9%	0. 01	0. 02	0. 12	0. 02	0. 04	0. 15	0. 02
Ti	99. 9%	<0. 001	<0. 001	<0. 001	<0. 001	<0. 001	<0. 001	<0. 001
Mn(electrolytic flake～50×25mm)		—	0. 92	8. 60	—	0. 35	0. 89	0. 05
V	99. 97%	0. 035	0. 040	0. 020	0. 034	0. 027	0. 015	0. 045
Zn	99. 95%	1. 16	3. 73	0. 72	0. 26	0. 60	0. 69	0. 01
Fe foil	99. 99%	0. 20	2. 88	3. 50	0. 33	1. 05	1. 86	0. 001
Cd	99. 50%	0. 089	2. 48	3. 05	0. 10	0. 14	0. 99	0. 012
Co	99. 99%	0. 014	0. 21	0. 55	0. 01	0. 06	0. 30	0. 002
In	99. 995%	0. 065	0. 02	0. 87	0. 09	0. 71	0. 21	0. 004
Ni	99. 9%	<0. 001	<0. 001	0. 06	0. 001	0. 02	0. 25	<0. 001
Mo		0. 003	0. 003	0. 003	0. 002	0. 005	0. 02	0. 003
Sn	99. 99%	<0. 001	<0. 001	0. 02	<0. 001	<0. 001	<0. 001	<0. 001
Pb foil	99. 90%	1. 06	1. 57	3. 10	0. 14	0. 65	0. 35	0. 06
W—sintered		0. 029	0. 030	0. 040	0. 030	0. 035	0. 030	0. 020
Cu foil	99. 99%	0. 02	0. 18	0. 60	0. 15	0. 19	0. 71	0. 003
Ag foil	99. 99%	<0. 001	<0. 001	<0. 001	<0. 001	<0. 001	<0. 001	<0. 001

Table 13. Corrosion of cadmium, zinc and steel by formaldehyde and propionic acids at 100% r.h. and 30°C for 3 weeks

	Corrosion in air space, g/dm³						
	Formaldehyde, vol-%		Propionic acid, vol.-%		Butyric acid, vol.-%		Control (no acid)
	0.01	0.10	0.01	0.10	0.01	0.10	
Zinc	0.05	3.50	0.05	0.10	0.05	0.04	0.01
Cadmium	0.08	0.06	0.07	1.13	0.08	0.20	0.01
Milld steel	0.01	0.002	0.30	3.20	0.13	1.60	0.01

Table 14. Corrosion of electrodeposited alloy coatings (10μm) on steel by acetic acid at 100% e.h. and 30°C for 3 weeks

Coating	Attack on plated steel specimens, g/dm²									
Solution Vol.-%	Nil	0.0001	0.001	0.01	0.04	0.07	0.10	0.40	0.70	1.0
ppm in air	Nilil	0.005	0.05	0.5	2.0	3.5	5.0	20	35	50
Mn	0.03	0.03	0.04	0.5	*	*	*	*	*	*
Mn/Se(99:1)	0.04	0.06	0.05	0.04	0.12	0.17	0.33	*	*	*
Mn/Zn(35:65)	0.13	0.16	0.17	0.50	0.66	*	*	*	*	*
Zn	0.01	0.02	0.03	0.25	*	*	*	*	*	*
Zn/Fe(60:40)	0.03	0.03	0.04	0.51	*	*	*	0.53	*	*
Zn/Ni(84:16)	0.005	0.01	0.008	0.06	0.10	0.20	0.21	0.35	0.51	0.68
Zn/In(76:24)	0.03	0.04	0.06	0.05	*	*	*	*	*	*
Cd	0.03	0.03	0.04	0.09	*	*	*	*	*	*
Cd/In(48·52)	0.02	0.02	0.02	0.09	0.30	*	*	*	*	*
Cd/Sn(70:30)	0.01	0.01	0.02	0.04	0.18	0.35	0.56	0.64	0.60	0.69

*coating corroded away completely

Table 15. Corrosion of nickel/chromium duplex coatings on steel sand brass by acetic and formic acid vapours at 100% r.h. and 30°C for 3 weeks

	Attack on plated steel and copper specimens, g/dm²			
	*Nickel/chromium duplex coating on steel		*Nickel/chromiumduplex coating on brass	
Coating thickness, μm	10	20	7.5	15
Acetic acid solution				
0.01 vol.-% (0.5ppm in air)	0.01	0.001	0.0007	—
0.1 vol.-% (5.0ppm in air)	0.11	0.02	0.002	0.0005
Formic acid solution				
0.01 vol.-% (0.6ppm in air)	0.02	0.005	0.001	0.0007
0.10 vol.-% (6.0ppm in air)	0.28	0.06	0.004	0.002

*Plated to B.S. 1224 : 1965