Section I: General Information

R. Baboian, Editor

Contents

Unified Numbering System for Metals and Alloys[1]

UNS SERIES	Metal
Nonferrous Metals and Alloys	
A00001-A99999	Aluminum and aluminum alloys
C00001-C99999	Copper and copper alloys
E00001-E99999	Rare earth and rare earth-like metals and alloys
L00001-L99999	Low melting metals and alloys
M00001-M99999	Miscellaneous nonferrous metals and alloys
N00001-N99999	Nickel and nickel alloys
P00001-P00999	Gold
P01001-P01999	Iridium
P02001-P02999	Osmium
P03001-P03999	Palladium
P04001-P04999	Platinum
P05001-P05999	Rhodium
P06001-P06999	Ruthenium
P07001-P07999	Silver
R01011-R01999	Boron
R02001-R02999	Hafnium
R03001-R03999	Molybdenum
R04001-R04999	Niobium (Columbium)
R05001-R05999	Tantalum
R06001-R06999	Thorium
R07001-R07999	Tungsten
R08001-R08999	Vanadium
R10001-R19999	Beryllium
R20001-R29999	Chromium
R30001-R39999	Cobalt
R40001-R49999	Rhenium
R50001-R59999	Titanium
R60001-R69999	Zirconium
Z00001-Z99999	Zinc and zinc alloys
Ferrous Metals and Alloys	
D00001-D99999	Specified mechanical properties steels
F00001-F99999	Cast irons
G00001-G99999	AISI and SAE carbon and alloys steels (except tool steels)
H00001-H99999	AISI H-steels
J00001-J99999	Cast steels (except tool steels)
K00001-K99999	Miscellaneous steels and ferrous alloys
S00001-S99999	Heat- and corrosion-resistant (stainless) steels
T00001-T99999	Tool steels
Welding Filler Metals, Classified by Weld Deposit Composition	
W00001-W09999	Carbon steel with no significant alloying elements
W10000-W19999	Manganese-molybdenum low-alloy steels
W20000-W29999	Nickel low-alloy steels
W30000-W39999	Austenitic stainless steels
W40000-W49999	Ferritic stainless steels
W50000-W59999	Chromium low-alloy steels
W60000-W69999	Copper-base alloys
W70000-W79999	Surfacing alloys
W80000-W89999	Nickel-base alloys

[1]See *NACE Corrosion Engineers Reference Book, Third Edition,* R. Baboian, Ed., NACE International, 2002, p. 233.

Examples of Common Names of Selected UNS Alloys[1]

Nonferrous

A02420 Al 242.0	A02950 Al 295.0	A03560 Al 356.0
A05140 Al 514.0	A05200 Al 520.0	A24430 Al B443.0
A91060 Al 1060	A91100 Al 1100	A92014 Al 2014
A92024 Al 2024	A93003 Al 3003	A95052 Al 5052
A95083 Al 5083	A95086 Al 5086	A95154 Al 5154
A96061 Al 6061	A96063 Al 6063	A97075 Al 7075
C10200 OF Copper	C11000 ETP Copper	C12200 DHP Copper
C14200 DPA Copper	C22000 Commercial Bronze	C23000 Red Brass
C26000 Cartridge Brass	C27000 Yellow Brass	C28000 Muntz Metal
C44300 Admiralty Brass, As	C44400 Admiralty Brass, Sb	C44500 Admiralty Brass, P
C46500 Naval Brass, As	C51000 Phosphor Bronze A	C52400 Phosphor Bronze D
C60600 Aluminum Bronze, 6 %	C61300 Aluminum Bronze, 7 %	C61400 Aluminum Bronze D
C63000 Nickel Aluminum Bronze	C65500 High-Silicon Bronze	C67500 Mangenese Bronze A
C68700 Aluminium Brass, As	C70600 90-10 Copper-Nickel	C71500 70-30 Copper-Nickel
C75200 Nickel Silver	C83600 Ounce Metal	C86500 Mangenese Bronze
C90500 Gun Metal	C92200 M Bronze	C95700 Cast Mn-Ni-Al Bronze
95800 Cast Ni-Al Bronze	C96400 Cast 70-30 Cu-Ni	
L50045 Common Lead	L51120 Chemical Lead	L55030 50/50 Solder
M11311 Mg AZ31B	M11914 Mg AZ91C	M12330 Mg EZ33A
M13310 Mg HK31A		
N02200 Nickel 200	N02201 Nickel 201	N02230 Nickel 230
N04400 400 Alloy	N04405 R-405 Alloy	N05500 K-500 Alloy
N05502 502 Alloy	N06002 X Alloy	N06007 G Alloy
N06022 C-22 Alloy	N06030 G-30 Alloy	N06110 Allcor
N06333 RA333 Alloy	N06455 C-4 Alloy	N06600 600 Alloy
N06601 601 Alloy	N06617 617 Alloy	N06625 625 Alloy
N06690 690 Alloy	N06975 2550 Alloy	N06965 G-3 Alloy
N07001 Waspaloy	N07031 31 Alloy	N07041 Rene 41
N07090 90 Alloy	N07716 625 Plus	N07718 718 Alloy
N07750 X-750 Alloy	N08020 20Cb-3	N08024 20Mo-4
N08026 20Mo-6	N08028 Sanicro 28	N08320 20 Mod
N08330 RA-330	N08366 AL-6X	N08367 AL-6XN
N08700 JS700	N08800 800 Alloy	N08801 801 Alloy
N08810 800H Alloy	N08811 800HT Alloy	N08825 825 Alloy
N08904 904L Alloy	N08925 25-6Mo	N09706 706 Alloy
N09925 925 Alloy	N10001 B Alloy	N10002 C Alloy
N10003 N Alloy	N10004 W Alloy	N10276 C-276 Alloy
N10685 B-2 Alloy		
R03600 Molybdenum	R03630 Molybdenum Alloy	R03650 Molybdenum, low C
R04210 Niobium (Columbium)	R05200 Tantalum	R07005 Tungsten
R30003 Elgiloy	R30004 Havar	R30006 Stellite 6
R30031 Stellite 31	R30035 MP35N	R30155 N-155

[1] See *NACE Corrosion Engineers Reference Book, Third Edition,* R. Baboian, Ed., NACE International, 2002, pp. 234–235.

Nonferrous		
R30188 HS-188 Alloy	R30260 Duratherm 2602	R30556 HS-556
R30605 L-605 Alloy	R50250 Titanium, Gr 1	R50400 Titanium, Gr 2
R50550 Titanium, Gr 3	R50700 Titanium, Gr 4	R52250 Titanium, Gr 11
R52400 Titanium, Gr 7	R53400 Titanium, Gr 12	R54520 Titanium, Gr 6
R56260 Ti6Al6Mo2Sn4Zr	R56320 Titanium, Gr 9	R56400 Titanium, Gr 5
R58640 Beta-C	R60702 Zr 702	R60704 Zr 704
R60705 Zr 705		
Z13000 Zinc Anode Type II	Z32120 Zinc Anode Type I	Z32121 Zinc Anode Type III
Ferrous		
F10006 Gray Cast Iron	F20000 Malleable Cast Iron	F32800 Ductile Iron 60-40-18
F41000Ni-Resist Type 1	F41002 Ni-Resist Type 2	F41006 Ni-Resist Type 5
F43000 Ductile Ni-Resist D2	F43006 Ductile Ni-Resist D5	F47003 Dunron
G10200 1020 Carbon Steel	G41300 4130 Steel	G43400 4340 Steel
J91150 CA-15	J91151 CA-15M	J91153 CA-40
J91540 CA-6NM	J91803 CB-30	J92500 CF-3
J92600 CF-8	J92602 CF-20	J92603 HF
J292605 HC	J92615 CC-50	J92701 CF-16F
J92710 CF-8C	J92800 CF-3M	J92900 CF-8M
J93000 CG-8M	J93001 CG-12	J93005 HD
J93370 CD-4MCu	J93402 CH-20	J93423 CE-30
J93503 HH	J94003 HI	J94202 CK-20
J94203 HK-30	J94204 HK-40	J94213 HN
J94224 HK	N08604 HL	N08002 HT
N08007 CN-7M	N08004 HU	N08705 HP
K01800 A516-55	K02100 A516-60	K02403 A516-65
K02700 A516-70	K02801 A285-C	K03005 A53-B
K03006 A106-B	K11510 0.2Cu Steel	K11522 C-0.5Mo
K11576 HSLA Steel	K11597 1.25Cr-0.5Mo	K21590 2.25Cr-1Mo
K41545 5Cr-0.5Mo	K81340 9Ni Steel	K90941 9Cr-1Mo
K94610 KOVAR		
S13800 PH 13-8 Mo	S15500 15-5 PH	S15700 PH 15-7 Mo
S17400 17-4 PH	S17600 Stainless W	S17700 17-7 PH
S20100 201 SS	S20200 202 SS	S20910 22-13-5
S21400 Tenelon	S21600 216 SS	S21800 Nitronic 60
S21900 21-6-9	S24000 18-3 Mn	S28200 18-18 Plus
S30200 302 SS	S30300 303 SS	S30400 304 SS
S30403 304L SS	S30409 304H SS	S30451 304N SS
S30453 304LN SS	S30500 305 SS	S30800 308 SS
S30815 253MA	S30900 309 SS	S30906 309S SS
S31000 310 SS	S31006 310S SS	S31200 44LN
S31254 254 SMO	S31260 DP-3	S31400 314 SS
S31500 3RE60	S31600 316 SS	S31603 316L SS
S31609 316H SS	S31635 316Ti SS	S31640 316Cb SS
S31651 316N SS	S31635 316LN SS	S31700 317 SS
S31703 317L SS	S31725 317LM SS	S31726 317L4 SS
S31803 2205 Alloy	S32100 321 SS	S32109 321H SS
S32304 SAF 2304	S32404 Uranus 50	S32550 Ferralium 255
S32900 329 SS	S32950 7-Mo Plus	S34700 347 SS
S34709 347H SS	S34800 348 SS	S35000 AM 350
S35500 AM 355	S36200 Almar 362	S38100 18-18-2
S40300 403 SS	S40500 405 SS	S40900 409 SS
S41000 410 SS	S41400 414 SS	S41600 416 SS
S41800 Greek Ascoloy	S42000 420 SS	S42200 422 SS
S42400 F6NM	S42900 429 SS	S43000 430 SS
S43100 431 SS	S43400 434 SS	S43500 436 SS
S44002 440A SS	S44003 440B SS	S44004 440C SS
S44200 442 SS	S44400 18-2	S44600 446 SS
S44625 26-1	S44626 26-1 Ti	S44627 26-1 Cb
S44635 26-4-4	S44660 SC-1	S44700 29-4
S44735 29-4C	S44800 29-4-2	S45000 Custom 450
S45500 Custom 455	S50100 5Cr-0.5Mo	S50200 5Cr-0.5Mo
S50300 7Cr-0.5Mo	S50400 9Cr-1Mo	S66286 A286

Designation: G 15–04

Standard Terminology Relating to Corrosion and Corrosion Testing[1]

This standard is issued under the fixed designation G 15; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This terminology covers commonly used terms in the field of corrosion. Related terms may be found in Terminologies D 16, D 4538, G 40, or other ASTM terminology standards. All terms defined by ASTM committees may be found in the *ASTM Dictionary of Engineering & Technology*.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D 16 Terminology for Paint, Related Coatings, Materials, and Applications

D 4538 Terminology Relating to Protective Coating and Lining Work for Power

G 40 Terminology Relating to Wear and Erosion

3. Terminology

AC impedance—See **electrochemical impedance**.

active—the negative direction of electrode potential. (Also used to describe corrosion and its associated potential range when an electrode potential is more negative than an adjacent depressed corrosion rate [passive] range.)

anion—a negatively charged ion.

anode—the electrode of an electrolytic cell at which oxidation is the principal reaction. (Electrons flow away from the anode in the external circuit. It is usually the electrode where corrosion occurs and metal ions enter solution.)

anode corrosion efficiency—the ratio of the actual corrosion (weight loss) of an anode to the theoretical corrosion (weight loss) calculated by Faraday's law from the quantity of electricity that has passed.

anodic inhibitor—a *corrosion inhibitor* whose primary action is to slow the kinetics of the anodic reaction, producing a positive shift in corrosion potential.

anodic polarization—the change of the electrode potential in the noble (positive) direction due to current flow. (See **polarization**.)

anodic protection—a technique to reduce the corrosion rate of a metal by polarizing it into its passive region where dissolution rates are low.

anolyte—the electrolyte adjacent to the anode of an electrolytic cell.

auxiliary electrode—See **counter electrode**.

breakdown potential—the least noble potential where pitting or crevice corrosion, or both, will initiate and propagate.

cathode—the electrode of an electrolytic cell at which reduction is the principal reaction. (Electrons flow toward the cathode in the external circuit.)

cathodic corrosion—corrosion of a metal when it is a cathode. (It usually happens to metals because of a rise in pH at the cathode or as a result of the formation of hydrides.)

cathodic inhibitor—a *corrosion inhibitor* whose primary action is to slow the kinetics of the cathodic reaction, producing a negative shift in corrosion potential.

cathodic polarization—the change of the electrode potential in the active (negative) direction due to current flow. (See **polarization**.)

cathodic protection—a technique to reduce the corrosion rate of a metal surface by making it the cathode of an electrochemical cell.

catholyte—the electrolyte adjacent to the cathode of an electrolytic cell.

cation—a positively charged ion.

caustic cracking—stress corrosion cracking of metals in caustic solutions. (See also **stress-corrosion cracking**.)

caustic embrittlement—See **caustic cracking**.

cavitation—the formation and rapid collapse within a liquid of cavities or bubbles that contain vapor or gas or both.

cavitation corrosion—the conjoint action of cavitation-erosion and corrosion.

cavitation damage—the degradation of a solid body resulting from its exposure to cavitation. (This may include loss of material, surface deformation, or changes in properties or appearance.)

cavitation-erosion—loss of material from a solid surface due to mechanical action of continuing exposure to cavitation.

chemical conversion coating—a protective or decorative nonmetallic coating produced *in situ* by chemical reaction of a metal with a chosen environment. (It is often used to prepare the surface prior to the application of an organic coating.)

[1] This terminology is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and are the direct responsibility of Subcommittee G01.02 on Terminology.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

concentration cell—an electrolytic cell, the emf of which is caused by a difference in concentration of some component in the electrolyte. (This difference leads to the formation of discrete cathode and anode regions.)

corrosion—the chemical or electrochemical reaction between a material, usually a metal, and its environment that produces a deterioration of the material and its properties.

corrosion fatigue—the process in which a metal fractures prematurely under conditions of simultaneous corrosion and repeated cyclic loading at lower stress levels or fewer cycles than would be required in the absence of the corrosive environment.

corrosion fatigue strength—the maximum repeated stress that can be endured by a metal without failure under definite conditions of corrosion and fatigue and for a specific number of stress cycles and a specified period of time.

corrosion inhibitor—a chemical substance or combination of substances that, when present in the proper concentration and forms in the environment, prevents or reduces corrosion.

corrosion potential—the potential of a corroding surface in an electrolyte relative to a reference electrode measured under open-circuit conditions.

corrosion rate—the amount of corrosion occurring in unit time. (For example, mass change per unit area per unit time; penetration per unit time.)

counter electrode—the electrode in an electrochemical cell that is used to transfer current to or from a test electrode.

crevice corrosion—localized corrosion of a metal surface at, or immediately adjacent to, an area that is shielded from full exposure to the environment because of close proximity between the metal and the surface of another material.

critical anodic current density—the maximum anodic current density observed in the active region for a metal or alloy electrode that exhibits active-passive behavior in an environment.

critical humidity—the relative humidity above which the atmospheric corrosion rate of some metals increases sharply.

critical pitting potential—the least noble potential where pitting corrosion will initiate and propagate. (See breakdown potential.)

current density—the electric current to or from a unit area of an electrode surface.

current efficiency—the ratio of the electrochemical equivalent current density for a specific reaction to the total applied current density.

deactivation—the process of prior removal of the active corrosive constituents, usually oxygen, from a corrosive liquid by controlled corrosion of expendable metal or by other chemical means, thereby making the liquid less corrosive.

dealloying—See **parting**.

depolarization—not a preferred term. (See **polarization**.)

deposit corrosion—localized corrosion under or around a deposit or collection of material on a metal surface. (See also **crevice corrosion**.)

dezincification—See **parting**; specific to copper-zinc alloys.

differential aeration cell (oxygen concentration cell)—a concentration cell caused by differences in oxygen concentration along the surface of a metal in an electrolyte. (See **concentration cell**.)

diffusion limited current density—the current density, often referred to as limiting current density, that corresponds to the maximum transfer rate that a particular species can sustain due to the limitation of diffusion.

electrochemical admittance—the reciprocal of the electrochemical impedance, $\Delta I/\Delta E$.

electrochemical cell—an electrochemical system consisting of an anode and a cathode in metallic contact and immersed in an electrolyte. (The anode and cathode may be different metals or dissimilar areas on the same metal surface.)

electrochemical impedance—the frequency dependent, complex valued proportionality factor, $\Delta E/\Delta I$, between the applied potential (or current) and the response current (or potential) in an electrochemical cell. This factor becomes the impedance when the perturbation and response are related linearly (the factor value is independent of the perturbation magnitude) and the response is caused only by the perturbation. The value may be related to the corrosion rate when the measurement is made at the corrosion potential.

electrochemical noise—fluctuations of the current, or both, originating from uncontrolled variations in a corrosion process.

electrochemical potential (electrochemical tension)—the partial derivative of the total electrochemical free energy of the system with respect to the number of moles of the constituent in a solution when all other factors are constant. (Analogous to the chemical potential of the constituent except that it includes the electrical as well as the chemical contributions to the free energy.)

electrode potential—the potential of an electrode in an electrolyte as measured against a reference electrode. (The electrode potential does not include any resistance losses in potential in either the solution or external circuit. It represents the reversible work to move a unit charge from the electrode surface through the solution to the reference electrode.)

electrolysis—production of chemical changes of the electrolyte by the passage of current through an electrochemical cell.

electrolytic cleaning—a process of removing soil, scale or corrosion products from a metal surface by subjecting it as an electrode to an electric current in an electrolytic bath.

Electromotive Force Series (EMF Series)—a list of elements arranged according to their standard electrode potentials, with "noble" metals such as gold being positive and "active" metals such as zinc being negative.

embrittlement—the severe loss of ductility or toughness or both, of a material, usually a metal or alloy.

environmentally-assisted cracking—the initiation or acceleration of a cracking process due to the conjoint action of a chemical environment and tensile stress.

equilibrium (reversible) potential—the potential of an electrode in an electrolytic solution when the forward rate of a given reaction is exactly equal to the reverse rate. (The equilibrium potential can only be defined with respect to a specific electrochemical reaction.)

erosion—the progressive loss of material from a solid surface due to mechanical interaction between that surface and a fluid, a multi-component fluid, or solid particles carried with the fluid.

erosion-corrosion—a conjoint action involving corrosion and erosion in the presence of a moving corrosive fluid, leading to the accelerated loss of material.

exchange current density—the rate of charge transfer per unit area when an electrode reaches dynamic equilibrium (at its reversible potential) in a solution; that is, the rate of anodic charge transfer (oxidation) balances the rate of cathodic charge transfer (reduction).

exfoliation—correction that proceeds laterally from the sites of initiation along planes parallel to the surface, generally at grain boundaries, forming corrosion products that force metal away from the body of the material, giving rise to a layered appearance.

external circuit—the wires, connectors, measuring devices, current sources, and so forth, that are used to bring about or measure the desired electrical conditions within the test cell.

filiform corrosion—corrosion that occurs under some coatings in the form of randomly distributed threadlike filaments.

fretting corrosion—the deterioration at the interface between contacting surface as the result of corrosion and slight oscillatory slip between the two surfaces.

galvanic corrosion—accelerated corrosion of a metal because of on electrical contact with a more noble metal or nonmetallic contactor in a corrosive electrolyte.

galvanic couple—a pair of dissimilar conductors, commonly metals, in electrical contact (See **galvanic corrosion**.)

galvanic current—the electric current between metals or conductive nonmetals in a galvanic couple.

galvanic series—a list of metals and alloys arranged according to their relative corrosion potentials in a given environment.

galvanodynamic—refers to a technique wherein current, continuously varied at a selected rate, is applied to an electrode in an electrolyte.

galvanostaircase—refers to a galvanostep technique for polarizing an electrode in a series of constant current steps wherein the time duration and current increments or decrements are equal for each step.

galvanostatic—an experimental technique whereby an electrode is maintained at a constant current in an electrolyte.

galvanostep—refers to a technique in which an electrode is polarized in a series of current increments or decrements.

grain dropping—the dislodgement and loss of a grain or grains (crystals) from a metal surface as a result of intergranular corrosion.

graphitic corrosion—the deterioration of metallic constituents in gray cast iron, which leaves the graphic particles intact. (The term "graphitization" is commonly used to identify this form of corrosion but is not recommended because of its use in metallurgy for the decomposition of carbide to graphite.)

hot corrosion—an accelerated corrosion of metal surfaces that results from the combined effect of oxidation and reactions with sulfur compounds and other contaminants, such as chlorides, to form a molten salt on a metal surface which fluxes, destroys, or disrupts the normal protective oxide.

hydrogen blistering—the formation of blisters on or below a metal surface from excessive internal hydrogen pressure. (Hydrogen may be formed during cleaning, plating, corrosion, and so forth.)

hydrogen embrittlement—hydrogen-induced cracking or severe loss of ductility caused by the presence of hydrogen in the metal.

immunity—a state of resistance to corrosion or anodic dissolution of a metal caused by thermodynamic stability of the metal.

impingement corrosion—a form of erosion-corrosion generally associated with the local impingement of a high-velocity, flowing fluid against a solid surface.

impressed current—an electric current supplied by a device employing a power source that is external to the electrode system. (An example is dc current for cathodic protection.)

intensiostatic—See **galvanostatic**.

intercrystalline corrosion—See **intergranular corrosion**.

intergranular corrosion—preferential corrosion at or adjacent to the grain boundaries of a metal or alloy.

internal oxidation—the formation of isolated particles of corrosion products beneath the metal surface. (This occurs as the result of preferential oxidation of certain alloy constituents by inward diffusion of oxygen, nitrogen, sulfur, and so forth.)

knife-line attack—intergranular corrosion of an alloy, usually stabilized stainless steel, along a line adjoining or in contact with a weld after heating into the sensitization temperature range.

local action corrosion—corrosion caused by local corrosion cells on a metal surface.

local corrosion cell—an electrochemical cell created on a metal surface because of a difference in potential between adjacent areas on that surface.

localized corrosion—corrosion at discrete sites, for example, pitting, crevice corrosion, and stress corrosion cracking.

long-line current—electric current through the earth from an anodic to a cathodic area of a continuous metallic structure. (Usually used only where the areas are separated by considerable distance and where the current result from concentration-cell action.)

Luggin probe or Luggin-Haber capillary—a device used in measuring the potential of an electrode with a significant current density imposed on its surface. (The probe minimizes the IR drop that would otherwise be included in the measurement and without significantly disturbing the current distribution on the specimen.)

macrocell corrosion—corrosion of a metal embedded in porous media (for example, concrete or soil) caused by concentration or galvanic cells which exist on a scale at least as large as the smallest major dimension of the corroding item (for example, the diameter of a bar pipe).

metal dusting—accelerated deterioration of metals in carbonaceous gases at elevated temperature to form a dust-like corrosion product.

metallizing—See **thermal spraying**.

microbial corrosion—corrosion that is affected by the action of microorganisms in the environment.

microbiologically influenced corrosion (MIC)—corrosion inhibited or accelerated by the presence or activity, or both, of microorganisms.

mixed potential—the potential of a specimen (or specimens in a galvanic couple) when two or more electrochemical reactions are occurring simultaneously.

noble—the positive (increasingly oxidizing) direction of electrode potential.

noble metal—a metal with a standard electrode potential that is more noble (positive) than that of hydrogen.

occluded cell—an electrochemical cell created at a localized site on a metal surface which has been partially obstructed from the bulk environment.

open-circuit potential—the potential of an electrode measured with respect to a reference electrode or another electrode when no current flows to or from it.

overvoltage—the change in potential of an electrode from its equilibrium or steady state value when current is applied.

oxidation—loss of electrons by a constituent of a chemical reaction. (Also refers to the corrosion of a metal that is exposed to an oxidizing gas at elevated temperatures.)

parting—the selective corrosion of one or more components of a solid solution alloy.

parting limit—the minimum concentration of a more noble component in an alloy, above which parting does not occur in a specific environment.

passivation—the process in metal corrosion by which metals become passive. (See **passive**.)

passivator—a type of inhibitor which appreciably changes the potential of a metal to a more noble (positive) value.

passive—the state of the metal surface characterized by low corrosion rates in a potential region that is strongly oxidizing for the metal.

passive-active cell—a corrosion cell in which the anode is a metal in the active state and the cathode is the same metal in the passive state.

pitting—corrosion of a metal surface, confined to a point or small area, that takes the form of cavities.

pitting factor—ratio of the depth of the deepest pit resulting from corrosion divided by the average penetration as calculated from weight loss.

polarization—the change from the open-circuit electrode potential as the result of the passage of current.

polarization admittance—the reciprocal of polarization resistance (di/dE).

polarization resistance—the slope (dE/di)at the corrosion potential of potential (E)—current density (i) curve. (It is inversely proportional to the corrosion current density when the polarization resistance technique is applicable.)

potentiodynamic—refers to a technique wherein the potential of an electrode with respect to a reference electrode is varied at a selected rate by application of a current through the electrolyte.

potentiostaircase—refers to a potentiostep technique for polarizing an electrode in a series of constant potential steps wherein the time duration and potential increments or decrements are equal for each step.

potentiostat—an instrument for automatically maintaining an electrode in an electrolyte at a constant potential or controlled potentials with respect to a suitable reference electrode.

potentiostatic—the technique for maintaining a constant electrode.

potentiostep—refers to a technique in which an electrode is polarized in a series of potential increments or decrements.

poultice corrosion—See **deposit corrosion.**

Pourbaix diagram (electrode potential-pH diagram)—a graphic representation showing regions of thermodynamic stability of species in metal-water electrolyte systems.

primary passive potential (passivation potential)—the potential corresponding to the maximum active current density (critical anodic current density) of an electrode that exhibits active-passive corrosion behavior.

protection potential—the most noble potential where pitting and crevice corrosion will not propagate.

redox potential—the potential of a reversible oxidation-reduction electrode measured with respect to a reference electrode, corrected to the hydrogen electrode, in a given electrolyte.

reduction—the gain of electrons by a constituent of a chemical reaction.

reference electrode—electrode having a stable and reproducible potential, which is used in the measurement of other electrode potentials.

rest potential—See **open-circuit potential**.

rust—a corrosion product consisting primarily of hydrated iron oxide. (A term properly applied only to ferrous alloys.)

sample—a portion of material taken from a larger quantity and representative of the whole, to be used for test purposes.

season cracking—See **stress-corrosion cracking**.

sensitization—a process resulting in a metallurgical condition which causes susceptibility of an alloy to intergranular corrosion or intergranular environmentally assisted cracking in a specific environment.

specimen—a prepared portion of a sample upon which a test is intended to be performed.

stray current corrosion—the corrosion caused by electric current from a source external to the intended electrical circuit, for example, extraneous current in the earth.

stress-corrosion cracking—a cracking process that requires the simultaneous action of a corrodent and sustained tensile stress. (This excludes corrosion-reduced sections which fail by fast fracture. It also excludes intercrystalline or transcrystalline corrosion which can disintegrate an alloy without either applied or residual stress.)

subsurface corrosion—See **internal oxidation**.

sulfidation—the reaction of a metal or alloy with a sulfur-containing species to produce a sulfur compound that forms on or beneath the surface of the metal or alloy.

Tafel slope—the slope of the straight line portion of a polarization curve, usually occurring at more than 50 mV from the open-circuit potential, when presented in a semi-logarithmic plot in terms of volts per logarithmic cycle of current density (commonly referred to as volts per decade).

thermal spraying—a group of processes wherein finely divided metallic or nonmetallic materials are deposited in a molten or semimolten condition to form a coating. (The coating material may be in the form of powder, ceramic rod, wire,or molten materials.)

thermogalvanic corrosion—the corrosive effect resulting from the galvanic cell caused by a thermal gradient across the metal surface.

transpassive region—the region of an anodic polarization curve, noble to and above the passive potential range, in which there is a significant increase in current density (increased metal dissolution) as the potential becomes more positive (noble).

tuberculation—the formation of localized corrosion products that appear on a surface as knoblike prominences (tubercules).

uniform corrosion—corrosion that proceeds at about the same rate over a metal surface.

weld decay—not a preferred term. Integranular corrosion, usually of stainless steels or certain nickel-base alloys, that occurs as the result of sensitization in the heat-affected zone during the welding operation.

working electrode—the test or specimen electrode in an electrochemical cell.

Glossary of Corrosion-Related Acronyms[1]

ABS	Acrylonitrile-butadiene-styrene plastics
AC	Air-cooled
AE	Acoustic emission
AES	Auger electron spectroscopy
ANN	Annealed
AUSS	Austenitic stainless steel
AVT	All volatile treatment for BFW
BFW	Boiler feedwater
BWR	Boiling water reactor
CAB	Cellulose acetate-butyrate
CCI	Crevice corrosion index
CCT	Critical crevice corrosion temperature
CD	Current density
CDA	Corrosion data acquisition
CF	Corrosion fatigue
CH	Cold work hardened
CHA	Cold work hardened, aged
CN	Concentric neutral
CP	Cathodic protection
CPP	Critical pitting potential
CPT	Critical pitting temperature
CPVC	Chlorinated poly(vinyl chloride)
CR	Cold-rolled
CRA	Corrosion-resistant alloy
CS	Carbon steel
CSE	Copper/copper sulfate electrode
CW	Cooling water
DCB	Double cantilever beam test
DIMA	Direct imaging mass analyzer
DSS	Duplex stainless steel
DTA	Differential thermal analysis
DW	Distilled water
EC	Environmental cracking
EDXA	Energy dispersive X-ray analysis
EIS	Electrochemical impedance spectroscopy
ELN	Electrochemical noise technique
EPMA	Electron beam microprobe analysis
EPDM	Ethylene propylene elastomer
EPR	Electrochemical potentiokinetic reactivation
ER	Electrical resistance
ESCA	Electron spectroscopy for chemical analysis
EW	Electric welded
FBC	Fluidized bed combustion
FBE	Fusion-bonded epoxy coating
FC	Furnace cooled
FCGR	Fatigue crack growth rate
FEP	Fluorinated ethylene propylene polymer
FGD	Flue gas desulfurization
FPM	Fluorocarbon elastomers
FRP	Fiber-reinforced plastic
FSS	Ferritic stainless steel
GMAW	Gas metal arc welding
GTAW	Gas tungsten arc welding
HAZ	Heat-affected zone
HB	Brinell hardness number
HE	Hydrogen embrittlement
HIC	Hydrogen induced cracking
HK	Knoop hardness number
HLLW	High level liquid waste (nuclear)
HPW	High-purity water
HR	Hot-rolled
HRA	Hot-rolled, aged
HRB	Rockwell B hardness number
HRC	Rockwell C hardness number
HSC	Hydrogen stress cracking
HSLA	High-strength low-alloy steel
HTR	Heat treatment
HVN	Vickers hardness number
IGC	Intergranular corrosion
IGSCC	Intergranular stress corrosion cracking
IMMA	Ion microprobe mass analyzer
IOZ	Inorganic zinc coating
ISS	Ion scattering spectroscopy
ISWS	Illinois State Water Survey tester
KIC	Critical stress intensity
LAS	Low-alloy steel
LMC	Liquid metal cracking
LSI	Langelier saturation index
MAS	Maraging steels
MCA	Multiple crevice assembly
MIC	Microbial induced corrosion
MSS	Martensitic stainless steel
MT	Magnetic particle inspection
NG	Nuclear grade
NHE	Normal hydrogen electrode
NMR	Nuclear magnetic resonance
NPS	Nominal pipe size
NT	Normalized and tempered

[1] See *NACE Corrosion Engineers Reference Book, Third Edition*, R. Baboian, Ed., NACE International, 2002, p. 33.

OCTG	Oil country tubular goods
OQ	Oil-quenched
OTEC	Ocean thermal energy conversion
OZ	Organic zinc coating
PC	Polycarbonate
PD	Pit depth
PE	Polyethylene
PFA	Perfluoro(alkoxy-alkane) copolymer
PHSS	Precipitaion hardenable stainless steel
PPC	Polymer modified portland cement
PP	Polypropylene
PR	Polarization resistance
PT	Dye penetrant survey
PTA	Polythionic acids
PTFE	Polytetrafluoromethylene
PU	Polyurethane
PVC	Poly(vinyl choloride)
PVDC	Poly(vinylidene chloride)
PVDF	Poly(vinylidene fluoride)
PWHT	Post-weld heat treatment
PWR	Pressurized water reactor
QT	Quenched and tempered
RH	Relative humidity
RSI	Ryzner saturation index
RT	X-ray or gamma ray survey
RTP	Reinforced thermoset plastics
RX	Recrystallized
SAM	Scanning Augar microscopy
SAW	Submerged arc welding
SBR	Styrene-butadiene rubber
SCC	Stress-corrosion cracking
SCE	Saturated calomel electrode
SEM	Scanning electron microscopy
SIMS	Secondary ion mass spectroscopy
SMAW	Shielded metal arc welding
SMLS	Seamless pipe or tubing
SMYS	Specified minimum yield strength
SRA	Stress relief anneal
SRB	Sulfate-reducing bacteria
SRC	Solvent-refined coal
S/N	Fatigue test
SRE	Scanning reference electrode
SS	Stainless steel
SSC	Sulfide stress cracking
SSMS	Spark sources mass spectroscopy
SSR	slow strain rate test
SSW	Substitute seawater
STA	Solution treated and aged
STEM	Scanning transmission electron microscopy
STQ	Solution treated and quenched
SW	Seawater
TEM	Transmission electron microscopy
TFE	Tetrafluoroethylene
TS	Tensile strength
TTS	Temperature, time, sensitization diagram
URD	Underground residential distribution systems
UT	Ultrasonic survey
UV	Ultraviolet spectroscopy
VCI	Volatile corrosion inhibitor
WFMT	Wet fluorescent magnetic particle inspection
WQ	Water-quenched
WOL	Wedge-opening load test
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
YS	Yield strength
ZRP	Zinc-rich paint

ASTM Standard Abbreviations and Unit Symbols

absolute	abs
academic degrees	use periods and run together (M.S., Ph.D., etc.)
alternating current, *n.*	AC
alternating current, *adj.*	A-C
American	Am.[a]
American wire gage	AWG
ampere	A
ampere hour	Ah
angstrom	Å
ante meridiem	a.m.
Association	Assn.[b]
atmosphere	atm
average	avg
barrel	bbl
becquerel	Bq
billion electronvolts	(use GeV, gigaelectronvolts)
Birmingham wire gage	BWG
brave horsepower	bhp
brake-horsepower hour	bhp · h
Brinell hardness number	HB (see ASTM E 10)
British thermal unit	Btu
Brown and Sharpe (gage)	B&S
bushel	bu
calorie	cal
candela	cd
centimetre	cm
centipoise	cP
centistokes	cSt
circular mil	cmil
coefficient	*spell out*
Company	Co.[b]
Corporation	Corp.[b]
coulomb	C
cubic	use exponential form[c]
cubic centimetre	cm^3
cubic decimetre	dm^3
curie	Ci
cycles per minute	cpm
cycles per second	(use Hz. hertz)
day	*spell out*
decibel	dB
degree (angle)	°
degree Celsius	°C
degree Fahrenheit	°F
degree Rankine	°R
degrees of freedom	df
Department	Dept.[b]
diameter	dia (in figures and tables only)
differential	d
direct current, *n.*	DC
direct current, *adj.*	D-C
Division	Div.[b]
dollar	$
effective horsepower	ehp
electromotive force	emf
electronvolt	eV
Engineers	Engrs.[a]
equation(s)	Eq(s)
farad	F
figure(s)	Fig(s).[d]
foot	ft
footcandle	fc
foot pound-force	ft · lbf (use for work, energy) (see lbf · ft)
gallon	gal
gauss	G
gilbert	Gb
grain	*spell out*
gram	g
gravity (acceleration)	*g*
gray	Gy
half hard	½ H
henry	H
hertz	Hz
horsepower	hp
horsepower hour	hp · h
hour	h
Hurter and Driffield scale (film density)	H&D
hydrogen ion concentration, negative logarithm of	pH
inch	in.
inch of mercury	in. Hg
inch of water	in. H_2O
inch pound-force	in · lbf (use for work, energy) (see lbf · in.)
inclusive	incl (in figures and tables only)
Incorporated	Inc.[b]
indicated horsepower	ihp
inside diameter	ID (in figures and tables only)
Institute	Inst.[b]
integrated neutron flux	nvt. n/cm^2
iron pipe size	IPS

joule	J
K alpha radiation	Kα
kelvin	K
kilocalorie	kcal
kilocycle per second	(see note on cycles per second)
kilogram	kg
kilogram-calorie	kg · cal
kilogram-force	kgf
kilogram metre	kg · m
kilometre	km
kilovolt	kV
kilovolt ampere	kVA
kiloelectronvolt	keV
kilovolt peak	kVp
kilowatt	kW
kilowatt hour	kWh
kip (1000 lbf)	*spell out*
kip (1000 lbf) per square inch	ksi
Knoop hardness number	HK (see ASTM E 384)
lambert	L
linear	*spell out*
litre	L
logarithm (common)	log
logorithm (natural)	ln
lumen	lm
lux	lx
magnetomotive force	mmf
mass-to-charge ratio	*m/e*
maximum	max (in figures and tables only)
maxwell	Mx
median effective concentration	EC_{50}
median effective dose	ED_{50}
median lethal concentration	LC_{50}
median lethal dose	LD_{50}
megacycles per second	(see note on cycles per second)
megawatt	MW
meta	*m*
metre	m
microampere	μA
microcurie	μCi
microfarad	μF
microgram	μg
microhenry	μH
microinch	μin.
microlitre	μL
micro-micro (prefix. use pico)	p
micrometre (formerly micron)	μm
microroentgen	μR
microsecond	μs
microvolt	μV
microwatt	μW
mil	*spell out*
mile	*spell out*
miles per hour	mph
milliampere	mA
milli-angstrom	mÅ
millicurie	mCi
milliequivalent	meq
milligram	mg
millihenry	mH
millilitre	mL
millimetre	mm
millimetre of mercury	mm Hg
million electronvolts	MeV
milliroentgen	mR
millisecond	ms
millivolt	mV
milliwatt	mW
minimum	min (in figures and tables only)
minute	min (*spell out* when used with minimum)
molal	*spell out*
molar	*M*
mole	mol
month (When followed by a date use Jan., Feb., March, April, May, June, July, Aug., Sept., Oct., Nov., Dec. When there is no date, *spell out*. Examples: Jan. 15, 1983; January 1983)	*spell out*
nanometre (formerly millimicron)	nm
National	Nat.[a]
newton	N
normal	*N*
number(s) (This abbreviation can often be omitted entirely. It is usually understood (as in *STP 325*, Specimen 8, Test 14, etc).)	No(s).[d]
oersted	Oe
ohm	Ω
ortho	*o*
ounce	oz
outside diameter	OD (in figures and tables only)
page	p.
pages	pp.
para	*p*
parts per billion	ppb
parts per million	ppm
pascal	Pa
per	use the diagonal line in expressions with unit symbols[e]
percent	%
pico (prefix)	p
picofarad	pF
pint	pt
poise	P
Poisson's ratio	μ (*ν* is preferred in applied mechanics)
post meridiem	p.m.
pound	lb
pound-force	lbf
pound-force foot	lbf · ft (use for torque) (see ft · lbf)
pound-force inch	lbf · in. (use for torque) (see in · lbf)
pound-force per square foot	lbf/ft^2
pound-force per square inch	psi or $lbf/in.^2$
pound-force per square inch absolute	psia

pound-force per square inch gage	psig
quart	qt
rad (dose unit)	rd
radian	rad
radio frequency, *n.*	rf
radio frequency, *adj.*	r-f
radius	R (in figures and tables only)
Railway	Ry.[b]
Railroad	R.R.[b]
reference(s)	Ref(s)
relative humidity	RH (in figures and tables only)
revolution per minute	r/min
revolution per second	r/s
Rockwell hardness, C scale	HRC (see ASTM E 18)
roentgen	R
root mean square	rms
Saybolt Furol seconds	SFS
Saybolt Universal seconds	SUS
second	s
secondary	*sec*
siemens	S
Society	Soc.[b]
socket joint (tables and drawings only)	S
specific gravity	sp gr
square	use exponential form (exception: psi, ksi)[c]
standard taper (tables and drawings only)	T
steradian	sr
stokes	St
tensile strength	*spell out*
tertiary	*tert*
tesla	T
thousand electronvolts	keV
thousand pounds	kip
thousand pounds-force per square inch	ksi
ton	*spell out*
torr	*spell out*
United States, *n.*	*spell out*
United States, *adj.*	U.S.
United Status Pharmacopeia	USP
versus	*spell out*
Vickers hardness number	HV (see ASTM E 92)
volt	V
volume (of a publication)	Vol[d]
watt	W
watt hour	Wh
weber	Wb
week	*spell out*
yard	yd
year	*spell out*
Young's modulus	*E*

[a]In footnotes and references only.
[b]At end of name only.
[c]With unit symbols only.
[d]Only when followed by a number.
[e]Exceptions: cpm, mph, psi.

International System of Units (SI)[1]

Quantity	Unit	Formula
	Base Units	
length	metre (m)	
mass	kilogram (kg)	
time	second (s)	
electric current	ampere (A)	
thermodynamic temperature	Kelvin (K)	
amount of substance	mole (mol)	
luminous intensity	candela (cd)	
	Supplementary Units	
plane angle	radian (rad)	
solid angle	steradian (sr)	
	Derived Units	
acceleration	metre per second squared	m/s^2
activity (of a radioactive source)	disintegration per second	(disintegration)/s
angular acceleration	radian per second squared	rad/s^2
angular velocity	radian per second	rad/s
area	square metre	m^2
density	kilogram per cubic metre	kg/m^3
electric capacitance	farad (F)	A · s/V
electric conductance	siemens (S)	A/V
electric field strength	volt per metre	V/m
electric inductance	henry (H)	V · s/A
electric potential difference	volt (V)	W/A
electric resistance	ohm (Ω)	V/A
electromotive force	volt (V)	W/A
energy	joule (J)	N · m
entropy	joule per kelvin	j/K
force	newton (N)	$kg \cdot m/s^2$
frequency	hertz (Hz)	(cycle)/s
illuminance	lux (lx)	lm/m^2
luminance	candela per square metre	cd/m^2
luminous flux	lumen (lm)	cd · sr
magnetic field strength	ampere per metre	A/m
magnetic flux	weber (Wb)	V · s
magnetic flux density	tesla (T)	Wb/m^2
magnetomotive force	ampere (A)	—
power	watt (W)	J/s
pressure	pascal (Pa)	N/m^2
quantity of electricity	coulomb (C)	A · s
quatity of heat	joule (J)	N · m
radiant intensity	watt per steradian	W/sr
specific heat	joule per kilogram-kelvin	J/kg · K
stress	pascal (Pa)	N/m^2
thermal conductivity	watt per metre-kelvin	W/m · K
velocity	metre per second	m/s
viscosity, dynamic	pascal-second	Pa·s
viscosity, kinematic	square metre per second	m^2/s
voltage	volt (V)	W/A
volume	cubic metre	m^3
wavenumber	reciprocal metre	(wave) m
work	joule (J)	N · m

[1] See ASTM E 380, Practice for Use of the International System of Units (SI) (The Modernized Metric System).

General Conversion Factors[1]

Unit	Conversion to	Multiply by	Reciprocal
Linear Measure			
mil (0.001 inch)	micrometre	25.4	0.03937
mil (0.001 inch)	millimetre	0.0254	39.37
inch	millimetre	25.4	0.03937
foot	metre	0.3048	3.281
yard	metre	0.9144	1.0936
mile	kilometre	1.6093	0.6214
nautical mile	kilometre	1.8532	0.5396
Square Measure			
square inch	square millimetre	645.2	0.00155
square inch	square centimetre	6.452	0.155
square foot	square metre	0.0929	10.764
square yard	square metre	0.8361	1.196
acre	hectare	0.4047	2.471
acre	square metre	4047.	0.0002471
acre	square foot	43560.	0.00002296
square mile	acre	640.	0.001562
square mile	square kilometre	2.590	0.3863
Volume			
cubic inch	cubic centimetre	16.387	0.06102
cubic foot	cubic metre	0.02832	35.31
cubic foot	gallon (U.S.)	7.48	0.1337
cubic foot	litre	28.32	0.03531
cubic yard	cubic metre	0.7646	1.3079
ounce (U.S., liq.)	cubic centimetre	29.57	0.03382
quart (U.S., liq.)	litre	0.9464	1.0566
gallon (U.S)	gallon (Imperial)	0.8327	1.2009
gallon (U.S)	litre	3.785	0.2642
barrel (U.S. Pertoleum)	gallon (U.S)	42.	0.028
barrel (U.S. Pertoleum)	litre	158.98	0.00629
Mass			
grain	milligram	64.8	0.01543
ounce (avoirdupois)	gram	28.35	0.03527
pound (avoirdupois)	kilogram	0.4536	2.205
short ton	metric ton	0.9072	1.1023
long ton	metric ton	1.0161	0.9842
Pressure or Stress			
atmosphere	mm Hg (@ 0°c)	760.	0.001316
atmosphere	pound force per inch^2	14.696	0.06805
atmosphere	bar	1.013	0.9872
atmosphere	megapascal (MPa)	0.1013	9.872
torr (mm Hg)	pascal	133.32	0.007501
inch of water	pascal	248.8	0.004019

[1] See ASTM E 380, Practice for Use of the International System of Units (SI) (The Modernized Metric System).

Unit	Conversion to	Multiply by	Reciprocal
foot of water	pound force per inch^2	0.4335	2.307
dyne per centimetre^2	pascal	0.1000	10.00
pound force per inch^2 (psi)	kilopascal (kPa)	6.895	0.1450
kip per inch^2 (ksi)	megapascal (MPa)	6.895	0.1450
pound force per inch^2	bar	0.06895	14.50
kilp per inch^2	kilogram per millimetre^2	0.7031	1.4223
Work, Heat, and Energy			
British thermal unit (Btu)	joule	1055.	0.0009479
foot pound–force	joule	1.356	0.7375
calorie	joule	4.187	0.2389
Btu	foot pound–force	778.	0.001285
kilocalorie	Btu	3.968	0.252
Btu	kilogram metre	107.56	0.009297
Btu per hour	watt	0.2929	3.414
watthour	joule	3600.	0.0002778
horse power	kilowatt	0.7457	1.341
Thermal Properties			
(Btu per foot^2, hour, °F) per inch	(kilocalorie per metre^2, hour, °C) per metre	0.1240	8.064
(Btu per foot^2, hour, °F) per inch	watt per metre, K	0.144	6.944
Btu per foot^2, hour, °F	kilocalorie per metre^2, hour, °C	4.882	0.2048
Btu per foot^2, hour, °F	watt per metre^2, K	5.674	0.1762
Btu per foot^2	kilocalories per metre^2	2.712	0.3687
Btu per foot^2	joule per metre^2	11360.	0.00008803
Miscellaneous			
pound per foot^3	kilogram per metre^3	16.02	0.06242
pound per gallon (U.S)	gram per litre	119.8	0.00835
grains per 100 foot^3	milligram per metre^3	22.88	0.0437
ounces per foot^3	gram per metre^2	305.2	0.003277
pound mole (gas)	cubic foot (STP)	359.	0.00279
gram mole (gas)	litre (STP)	22.4	0.0446
day	minute	1440.	0.000694
week	hour	168.	0.00595
year	hour	8766.	0.0001141
U.S. bag cement	kilogram	42.63	0.02346
gallon (U.S) per bag cement	litre per kilogram	0.0888	11.26
ksi (inch)$^{1/2}$	megapascal (metre)$^{1/2}$	1.0989	0.9100
cubic foot of water (60°F)	pound of water	62.37	0.01603
board foot	cubic metre	0.00236	423.7
milliampere per foot^2	milliampere per metre^2	10.76	0.0929
gallons (U.S.) per minute	metre^3 per day	5.451	0.1835
pound–force	newton	4.448	0.2248

Condensed Metric Practice Guide for Corrosion[1,2]

Multiply	By	To Convert to SI Units:
	Area	
$inch^2$	645.2	millimetre^2 (mm^2)
$inch^2$	6.452	centimetre^2 (cm^2)
$foot^2$	0.092 90	metre^2 (m^2)
$foot^2$	929.0	centimetre^2 (cm^2)
$yard^2$	0.836 1	metre^2 (m^2)
	Bending Moment (Torque)	
dyne centimetre	0.000 000 1	newton metre (N·m)
pound-force inch	0.113 0	newton metre (N·m)
pound-force foot	1.356	newton metre (N·m)
	Corrosion Rate	
mil per year (mpy)	0.025 40	millimetre per year (mm/y)[a]
mil per year	25.40	micrometre per year (mm/y)
inch per year (ipy)	25.40	millimetre per year (mm/y)
inch per month (ipm)	304.8	millimetre per year (mm/y)
milligram per decimetre^2 day (mdd)	0.100 0	gram per metre^2 day ($g/m^2 \cdot d$)[a]
milligram per decimetre^2 day	0.004 167	gram per metre^2 hour ($g/m^2 \cdot h$)
milligram per decimetre^2 day	100.0	milligram per metre^2 day ($mg/m^2 \cdot d$)
	Current Density	
milliampere per millimetre^2	1000.	ampere per metre^2 (A/m^2)
milliampere per centimetre^2	10.00	ampere per metre^2 (A/m^2)
microampere per centimetre^2	0.010 00	ampere per metre^2 (A/m^2)
milliampere per metre^2	0.001 000	ampere per metre^2 (A/m^2)
microampere per millimetre^2	1.000	ampere per metre^2 (A/m^2)
microampere per foot^2	10.76	milliampere per metre^2 (mA/m^2)
ampere per inch^2	1 550.	ampere per metre^2 (A/m^2)
ampere per foot^2	10.76	ampere per metre^2 (A/m^2)
ampere per centimetre^2	10 000.	ampere per metre^2 (A/m^2)
ampere per decimetre^2	100.0	ampere per metre^2 (A/m^2)
	Energy	
British thermal unit (Btu) (60°F)	1055.	joule (J)
calorie (mean)	4.190	joule (J)
foot-pound-force	1.356	joule (J)
kilocalorie (mean)	4190.	joule (J)
kilowatt hour	3.600	megajoule (MJ)
	Flow, Volume Per Unit Time	
$foot^3$ per second	0.028 32	metre^3 per second (m^3/s)
$foot^3$ per second	2445.	metre^3 per day (m^3/d)
$foot^3$ per minute	40.78	metre^3 per day (m^3/d)
gallon (U.S. liquid) per minute	5.451	metre^3 per day (m^3/d)
gallon (U.S. liquid) per hour	0.090 85	metre^3 per day (m^3/d)
gallon (U.S. liquid) per day	0.003 785	metre^3 per day (m^3/d)
	Force	
dyne	0.000 01	newton (N)
kilogram-force	9.807	newton (N)
ounce-force	0.278 0	newton (N)
pound-force	4.448	newton (N)
	Length	
angstrom	1×10^{-10}	metre (m)
angstrom	0.100 0	nanometre (nm)
micron	0.001 0	millimetre (mm)
micron	1.000	micrometre (μm)
mil	0.025 40	millimetre (mm)
mil	25.40	micrometre (μm)

Multiply	By	To Convert to SI Units:
inch	2.540	centimetre (cm)
inch	25.40	millimetre (mm)
inch	25 400.	micrometre (μm)
foot	0.304 8	metre (m)
yard	0.914 4	metre (m)
mile	1.609	kilometre (km)
	Mass	
grain	64.80	milligram (mg)
ounce	28.35	gram (g)
pound	0.453 6	kilogram (kg)
pound	453.6	gram (g)
ton (short, 2000 lb)	907.2	kilogram (kg)
	Mass Per Unit Area	
ounce-mass per foot^2	305.1	gram per metre^2 (g/m^2)
pound-mass per foot^2	4.882	kilogram per metre^2 (kg/m^2)
pound-mass per foot^2	4882.	gram per metre^2 (g/m^2)
pound-mass per inch^2	703.1	kilogram per metre^2 (kg/m^2)
	Mass Per Unit Volume (Density)	
gram per centimetre^3	1000.	kilogram per metre^3 (kg/m^3)
ounce (mass) per inch^3	1730.	kilogram per metre^3 (kg/m^3)
ounce (mass) per gallon (U.S. liquid)	7.489	kilogram per metre^3 (kg/m^3)
ounce (mass) per gallon (U.S. liquid)	7.489	gram per litre (g/L)
pound (mass) per foot^3	16.02	kilogram per metre^3 (kg/m^3)
pound (mass) per gallon (U.S. liquid)	119.8	kilogram per metre^3 (kg/m^3)
	Power	
Btu (thermochemical) per second	1054.	watt (W)
horsepower (electric)	746.0	watt (W)
kilocalorie (thermochemical) per second	4184.	watt (W)
	Pressure or Stress	
atmosphere (normal = 760 torr)	101 300.	pascal (Pa)
centimetre of mercury (0°C)	1 333.	pascal (Pa)
dyne per centimetre^2	0.100 0	pascal (Pa)
inch of mercury (60°F)	3377.	pascal (Pa)
inch of water (60°F)	248.8	pascal (Pa)
kilogram-force per metre^2	9.807	pascal (Pa)
kip per inch^2	6.895	megapascal (MPa)
pound-force per inch^2	6.895	kilopascal (kPa)
pound-force per foot^2	47.88	pascal (Pa)
	Stress Intensity	
(pound-force per inch^2) inch$^{1/2}$	0.034 75	newton per millimetre$^{3/2}$ (N/mm$^{3/2}$)
(kip per inch^2) inch$^{1/2}$	34.75	newton per millimetre$^{3/2}$ (N/mm$^{3/2}$)
(pound-force per inch^2) inch$^{1/2}$	0.001 099	megapascal metre$^{1/2}$ (MPa ·m$^{1/2}$)[a]
(kip per inch^2) inch$^{1/2}$	1.099	megapascal metre$^{1/2}$ (MPa ·m$^{1/2}$)[a]
	Temperature	
degree Celsius	$T_K = T_C^\circ + 273.15$	kelvin (k)
degree Fahrenheit	$T_C^\circ = (T_F^\circ - 32)/1.8$	degree Celsius (°C)
	Time	
hour (mean solar)	3600.	second (s)
day (mean solor)	86 400.	second (s)
month (calendar)	2.628	megasecond (Ms)
year (calendar)	31.54	megasecond (Ms)
	Velocity (Speed)	
inch per second	25.40	millimetre per second (mm/s)
foot per second	0.304 8	metre per second (m/s)
Inch per minute	0.423 3	millimetre per second (mm/s)
mile per hour	1.609	kilometre per hour (km/h)
mile per hour	0.447 0	metre per second (m/s)
	Volume	
inch[1]	16.39	centimetre^3 (cm^3)
fluid ounce (U.S.)	29.57	centimetre^3 (cm^3)
pint (U.S. liquid)	473.2	centimetre^3 (cm^3)
quart (U.S. liquid)	946.4	centimetre^3 (cm^3)
gallon (U.S. liquid)	0.003 785	metre^3 (m^3)
gallon (U.S. liquid)	3.785	litre (L)

[1]This condensed guide is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals.
[2]This guide is based on ASTM E 380.
[a]Preferred units.

Multiplication Factors[1]

Multiplication Factor	Prefix	Symbol
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{4}	mega	M
1 000 = 10^{3}	kilo	k
1 00 = 10^{2}	hecto[a]	h
1 0 = 10^{1}	deka[a]	da
0.1 = 10^{-1}	deci[a]	d
0.01 = 10^{-2}	centi[a]	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

[a]To be avoided where practical.

Relationships among Some of the Units Commonly Used for Corrosion Rates[2]

Unit	Factor for Conversion to					
	mdd	$g/m^2/d$	μm/yr	mm/yr	mils/yr	in./yr
Milligrams per square decimetre per day (mdd)	1	0.1	36.5/*d*	0.365/*d*	1.144/*d*	0.00144/*d*
Grams per square metre per day ($g/m^2/d$)	10	1	365/*d*	0.365/*d*	14.4/*d*	0.0144/*d*
Micrometres per year (μm/yr)	0.0274*d*	0.00274*d*	1	0.001	0.0394	0.0000394
Millimetres per year (mm/yr)	27.4*d*	2.74*d*	1000	1	39.4	0.0394
Mils per year (mils/yr)	0.696*d*	0.0696*d*	25.4	0.0254	1	0.001
Inches per year (in./yr)	696*d*	69.6*d*	25400	25.4	1000	1

NOTE: *d* is metal density in grams per cubic centimetre (g/cm^3).

[1] See ASTM E 380, Practice for Use of the International System of Units (SI) (The Modernized Metric System).

[2] Wranglén, G. An Introduction to Corrosion and Protection of Metals, Chapman and Hall, 1985, p. 233.

Corrosion Rate Calculation (from Mass Loss)[1]

$$\text{Corrosion rate} = \frac{(K \times W)}{(A \times T \times D)}$$

where

K = a constant (see below),
T = time of exposure in hours to the nearest 0.01 h,
A = area in cm^2 to the nearest 0.01 cm^2,
W = mass loss in g, to nearest 1 mg (corrected for any loss during cleaning (see 9.4)), and
D = density in g/cm^3, (see Appendix X1 of ASTM G 1).

Many different units are used to express corrosion rates. Using the above units for T, A, W, and D, the corrosion rate can be calculated in a variety of units with the following appropriate value of K:

Corrosion Rate Units Desired	Constant (K) in Corrosion Rate Equation
mils per year (mpy)	3.45×10^6
inches per year (ipy)	3.45×10^3
inches per month (ipm)	2.87×10^2
millimetres per year (mm/y)	8.76×10^4
micrometres per year (μm/y)	8.76×10^7
picometres per second (pm/s)	2.78×10^6
grams per square metre per hour ($g/m^2 \cdot h$)	$1.00 \times 10^4 \times D^a$
milligrams per square decimeter per day (mdd)	$2.40 \times 10^6 \times D^a$
micrograms per square metre per second ($\mu g/m^2 \cdot s$)	$2.78 \times 10^6 \times D^a$

[a]Density is not needed to calculate the corrosion rate in these units. The density in the constant K cancels out the density in the corrision rate equation.

[1]See ASTM G 1, Practice for Preparing, Cleaning and Evaluating Corrosion Test Specimens.

Corrosion Rate Conversion Factors

$$\text{Mils/year (mpy)} = C \times \frac{\text{weight loss}}{\text{area} \times \text{time}} \times K$$

Millimetres/year (mm/y) = 0.0254 mpy

Weight Loss	Area	C Factors				
		Hour	Day	Week	Month	Year
mg	cm^2	437	18.2	2.59	0.598	0.0498
	dm^2	4.37	0.182	0.0259	5.98×10^{-3}	4.98×10^{-4}
	m^2	0.0437	1.82×10^{-3}	2.59×10^{-4}	5.98×10^{-5}	4.98×10^{-6}
	in^2	67.7	2.82	0.402	0.0927	7.72×10^{-3}
	ft^2	0.470	0.0196	2.79×10^{-3}	6.44×10^{-4}	5.36×10^{-5}
g	cm^2	437×10^3	182×10^2	2590	598	49.8
	dm^2	4370	182	25.9	5.98	0.498
	m^2	43.7	1.82	0.259	0.0598	4.98×10^{-3}
	in^2	677×10^2	2820	402	92.7	7.72
	ft^2	470	19.6	2.79	0.644	0.0536
lb	cm^2	198×10^6	825×10^4	118×10^4	271×10^3	226×10^2
	dm^2	198×10^4	825×10^2	118×10^2	2710	226
	m^2	198×10^2	825	118	27.1	2.26
	in^2	307×10^5	128×10^4	182×10^3	420×10^2	3500
	ft^2	213×10^3	8880	1270	292	24.3

K is a density factor
K = 1.000 for carbon steel
K factors for other alloys are given on the next page

EXAMPLE: A 5.0 square inch specimen of copper has a weight loss of 218 mg in 40 hour corrosion test.

$$\text{mpy} = 67.7 \times \frac{218}{5.0 \times 40} \times 0.88 = 65$$

$$\text{mm/yr} = 0.0254 \times 65 = 1.65$$

[1]See *NACE Corrosion Engineers Reference Book, Second Edition,* R. S. Treseder, R. Baboian, and C. G. Munger, Eds., NACE International, Houston, TX, 1991.

Densities of Common Alloys[1]

(K = ratio of carbon steel density to that of alloy)

UNS	Common Name	Density g/cm³	K	UNS	Common Name	Density g/cm³	K
A91100	Al 1100	2.72	2.89	N06007	G Alloy	8.34	0.94
A93003	Al 3003	2.74	2.87	N06022	C-22 Alloy	8.69	0.90
A95052	Al 5052	2.68	2.93	N06030	G-30 Alloy	8.22	0.96
A96061	Al 6061	2.70	2.91	N06455	C-4 Alloy	8.64	0.91
A97075	Al 7075	2.80	2.81	N06600	600 Alloy	8.47	0.93
C11000	ETP Copper	8.94	0.88	N06601	601 Alloy	8.11	0.97
C22000	Commercial Bronze	8.89	0.88	N06625	625 Alloy	8.44	0.93
C23000	Red Brass	8.75	0.90	N06985	G-3 Alloy	8.30	0.95
C26000	Cartridge Brass	8.53	0.92	N07001	Waspaloy	8.19	0.96
C27000	Yellow Brass	8.39	0.94	N07041	Rene 41	8.25	0.95
C28000	Muntz Metal	8.39	0.94	N07718	718 Alloy	8.19	0.96
C44300	Admiralty brass. As	8.52	0.92	N07750	X-750 Alloy	8.28	0.95
C46500	Naval Brass. As	8.41	0.93	N08020	20Cb-3	8.08	0.97
C51000	Phosphor Bronze A	8.86	0.89	N08024	20Mo-4	8.11	0.97
C52400	Phosphor Bronze D	8.78	0.90	N08026	20M0-6	8.13	0.97
C61300	Aluminum Bronze 7 %	7.69	1.00	N08028	Sanicro 28	8.0	0.98
C61400	Aluminum Bronze D	7.78	1.01	N08366	AL-6X	8.0	0.98
C63000	Ni-Al Bronze	7.58	1.04	N08800	800 Alloy	7.94	0.99
C65500	High-Silicon Bronze	8.52	0.92	N08825	825 Alloy	8.14	0.97
C67500	Manganese Bronze A	8.36	0.94	N08904	904L Alloy	8.0	0.98
C68700	Aluminum Brass. As	8.33	0.94	N08925	25-6Mo	8.1	0.97
C70600	9-10 Copper-Nickel	8.94	0.88	N09925	925 Alloy	8.05	0.98
C71500	70-30 Copper-Nickel	8.94	0.88	N10003	N Alloy	8.79	0.89
C75200	Nickel Silver	8.73	0.90	N10004	W Alloy	9.03	0.87
C83600	Ounce Metal	8.80	0.89	N10276	C-276 Alloy	8.89	0.88
C86500	Manganese Bronze	8.3	0.96	N10665	B-2 Alloy	9.22	0.85
C90500	Gun Metal	8.72	0.90	R03600	Molybdenum	10.22	0.77
C92200	M Bronze	8.64	0.91	R04210	Niobium	8.57	0.92
C95700	Cast Mn-Ni-Al Bronze	7.53	1.04	R05200	Tantalum	16.60	0.47
C95800	Cast Ni-Al Bronze	7.64	1.03	R50250	Titanium, Gr 1	4.54	1.73
F10006	Gray Cast Iron	7.20	1.09	R50400	Titanium, Gr 2	4.54	1.73
F20000	Malleable Cast Iron	7.27	1.08	R53400	Titanium, Gr 12	4.52	1.74
F32800	Ductile Iron	7.1	1.11	R56400	Titanium, Gr 5	4.43	1.77
F41002	Ni-Resist Type 2	7.3	1.06	R60702	Zr 702	6.53	1.20
F43006	Ductile Ni-Resist, D5	7.68	1.02	S20100	201 SS	7.94	0.99
F47003	Duriron	7.0	1.12	S20200	202 SS	7.94	0.99
G10200	1020 Carbon Steel	7.86	1.00	S30400	304 SS	7.94	0.99
G41300	4130 Steel	7.86	1.00	S30403	304L SS	7.94	0.99
J91150	CA-15 Cast SS	7.61	1.03	S30900	309 SS	7.98	0.98
J91151	CA-15M Cast SS	7.61	1.03	S31000	310 SS	7.98	0.98
J91540	CA-6NM Cast SS	7.7	1.02	S31254	254 SMO	8.0	0.98
J92600	CF-8 Cast SS	7.75	1.01	S31500	3RE60	7.75	1.01
J92800	CF-3MN Cast SS	7.75	1.01	S31600	316 SS	7.98	0.98
J92900	CF-8M Cast SS	7.75	1.01	S31603	316L SS	7.98	0.98
J94204	HK-40 Cast SS	7.75	1.01	S31700	317 SS	7.98	0.98
J95150	CN-7M Cast SS	8.00	0.98	S32100	321 SS	7.94	0.99
K11597	1.25Cr-0.5Mo Steel	7.85	1.00	S32550	Ferralium 255	7.81	1.01
K81340	9Ni Steel	7.86	1.00	S32950	7 Mo Plus	7.75	1.01
L51120	Chemical Lead	11.3	0.70	S34700	347 SS	8.03	0.98
M11311	Mg AZ31B	1.77	4.44	S41000	410 SS	7.70	1.02
N02200	Nickel 200	8.89	0.88	S43000	430 SS	7.72	1.02
N04400	400 Alloy	8.80	0.89	S44600	446 SS	7.65	1.03
N05500	K-500 Alloy	8.44	0.93	S50100	5Cr-0.5Mo Steel	7.82	1.01
N06002	X Alloy	8.23	0.95	S50400	9Cr-1Mo Steel	7.67	1.02

[1]See *NACE Corrosion Engineers Reference Book, Third Edition*, R. Baboian, Ed., NACE International, 2002, p.105.

Table 1—Overvoltage values

$n = b \log i / i_0$

HYDROGEN OVERVOLTAGE

Material	Ovevoltage (Volts) at 1 ma/cm^2 25°C, 2 N H_2SO_4
Platinum (Platinized)	0.0005
Platinum (Smooth)	0.15
Palladium	0.05
Nickel	0.25
Iron	0.40
Tungsten	0.2
Molybdenum	0.15
Bismuth	0.70
Lead	1.2
Tin	0.65
Carbon	0.5
Aluminum	0.70
Mercury	1.15
Cadminum	0.9
Zinc	0.85
Gold	0.15
Silver	0.30
Copper	0.5

OXYGEN OVERVOLTAGE

Material	Overvoltage (Volts) at 1 ma/cm^2 25°C, 1 N KOH
Platinum (Platinized)	0.52
Platinum (Smooth)	0.82
Nickel	0.53
Graphite	0.89
Gold	0.96
Silver	0.73
Copper	0.58

Data from: *The Encyclopedia of Electrochemistry*, Reinhold, NY, 1964. Glasstone's *Textbook of Physical Chemistry*, Van Nostrand, NY, 1958. Kochler's *Electrochemistry*, 2nd Edition, Wiley, NY, 1950. Uhilg's *Corrosion and Corrosion Control*, Wiley, NY, 1971.

Standard Reference Potentials and Conversion Table[1]

Reference Potentials and Conversion Factors

Electrode	Potential (V) at 25°C		Thermal Temperature Coefficient[A]
	E'^{B}	E''^{C}	(mV/°C)
(Pt)/H_2(α = 1)/H^+ (α = 1)(SHE)	0.000	...	+0.87
Ag/AgCl/1*M* KCl	+0.235	...	+0.25
Ag/AgCl/0.6 M Cl^- (seawater)	+0.25	...	...
Ag/AgCl/0.1 M Cl^-	+0.288	...	+0.22
Hg/Hg_2Cl_2/sat KCl (SCE)	+0.241	+0.244	+0.22
Hg/Hg_2Cl_2/1*M* KCl	+0.280	0.283	+0.59
Hg/Hg_2Cl_2/0.1*M* KCl	+0.334	0.336	+0.79
Cu/$CuSO_4$ sat	+0.30	...	+0.90
Hg/Hg_2SO_4/H_2SO_4[D]	+0.616	...	...

[A] To convert from thermal to isothermal temperature coefficients, subtract 0.87 mV/°C. Thus the isothermal temperature coefficient for Ag-AgCl is – 0.62 mV/°C.

[B] E' is the standard potential for the half cell corrected for the concentration of the ions.

[C] E'' also inclues the liquid junction potentials for a saturated KCl salt bridge. To convert from one scale to another, add the value indicated.

[D] Potential given is for a range of H_2SO_4 molalities as discussed in Ref (*10*).

From (E')	To SHE Scale	To SCE Scale (E')
H_2/H^+	...	–0.241
Ag/AgCl/1 *M* KCl	+0.235	–0.006
Ag/AgCl/0.6 *M* Cl (seawater)	+0.25	+0.009
Ag/AgCl/0.1 *M* Cl	+0.288	+0.047
Hg/Hg_2/Cl_2/sat KCl (SCE)	+0.241	...
Hg/Hg_2Cl_2, 1 *M*	+0.280	+0.039
Hg/Hg_2Cl_2, 0.1 *M*	+0.334	0.093
Cu/$CuSO_4$ sat	+0.30	+0.06
Hg/Hg_2SO_4/H_2SO_4	+0.616	...

Example:

An electrode potential of +1.000 V versus SCE would be (1.000 + 0.241) ± +1.241 V versus SHE. An electrode potential of –1.000 V versus SCE would give (–1.000 + 0.241) = –0.759 V versus SHE.

[1] See ASTM G 3, Practice for Conversions Applicable to Electrochemical Measurements in Corrosion Testing.

Equivalent Weight Values for Metals and Alloys[1]

Common Designation	UNS	Elements w/Constant Valence	Lowest		Second		Third		Fourth	
			Variable Valence	Equivalent Weight	Variable Valence	Equivalent Weight	Element/ Valence	Equivalent Weight	Element/ Valence	Equivalent Weight
Aluminum Alloys										
AA1100	A91100	Al/3		8.99						
AA2024	A92024	Al/3, Mg/2	Cu/1	9.38	Cu/2	9.32				
AA2219	A92219	Al/3	Cu/1	9.51	Cu/2	9.42				
AA3003	A93003	Al/3	Mn/2	9.07	Mn/4	9.03	Mn 7	8.98		
AA3004	A93004	Al/3, Mg/2	Mn/2	9.09	Mn/4	9.06	Mn 7	9.00		
AA5005	A95005	Al/3, Mg/2		9.01						
AA5050	A95050	Al/3, Mg/2		9.03						
AA5052	A95052	Al/3, Mg/2		9.05						
AA5083	A95083	Al/3, Mg/2		9.09						
AA5086	A95086	Al/3, Mg/2		9.09						
AA5154	A95154	Al/3, Mg/2		9.08						
AA5454	A95454	Al/3, Mg/2		9.06						
AA5456	A95456	Al/3, Mg/2		9.11						
AA6061	A96061	Al/3, Mg/2		9.01						
AA6070	A96070	Al/3, Mg/2, Si/4		8.98						
AA6101	A96161	Al/3		8.99						
AA7072	A97072	Al/3, Zn/2		9.06						
AA7075	A97075	Al/3, Zn/2, Mg/2	Cu/1	9.58	Cu/2	9.55				
AA7079	A97079	Al/3, Zn/2, Mg/2		9.37						
AA7178	A97178	Al/3, Zn/2, Mg/2	Cu/1	9.71	Cu/2	9.68				
Copper Alloys										
CDA110	C11000		Cu/1	63.55	Cu/2	31.77				
CDA220	C22000	Zn/2	Cu/1	58.07	Cu/2	31.86				
CDA230	C23000	Zn/2	Cu/1	55.65	Cu/2	31.91				
CDA260	C26000	Zn/2	Cu/1	49.51	Cu/2	32.04				
CDA280	C28000	Zn/2	Cu/1	46.44	Cu/2	32.11				
CDA444	C44300	Zn/2	Cu/1, Sn/2	50.42	Cu/1, Sn/4	50.00	Cu/2, Sn/4	32.00		
CDA687	C68700	Zn/2, Al/3	Cu/1	48.03	Cu/2	30.29				
CDA608	C60800	Al/3	Cu/1	47.114	Cu/2	27.76				
CDA510	C51000		Cu/1, Sn/2	63.32	Cu/1, Sn/4	60.11	Cu/2, Sn/4	31.66		
CDA524	C52400		Cu/1, Sn/2	63.10	Cu/1, Sn/4	57.04	Cu/2, Sn/4	31.55		
CDA655	C65500	Si/4	Cu/1	50.71	Cu/2	28.51				
CDA706	C70600	Ni/2	Cu/1	56.92	Cu/2	31.51				
CDA715	C71500	Ni/2	Cu/1	46.69	Cu/2	30.98				
CDA752	C75200	Ni/2, Zn/2	Cu/1	46.38	Cu/2	31.46				
Stainless Steels										
304	S30400	Ni/2	Fe/2, Cr/3	25.12	Fe/3, Cr/3	18.99	Fe/3, Cr/6	15.72		
321	S32100	Ni/2	Fe/2, Cr/3	25.13	Fe/3, Cr/3	19.08	Fe/3, Cr/6	15.78		
309	S30900	Ni/2	Fe/2, Cr/3	24.62	Fe/3, Cr/3	19.24	Fe/3, Cr/6	15.33		
310	S31000	Ni/2	Fe/2, Cr/3	24.44	Fe/3, Cr/3	19.73	Fe/3, Cr/6	15.36		
316	S31600	Ni/2	Fe/2, Cr/3, Mo/3	25.50	Fe/3, Cr/3, Mo/4	25.33	Fe/3, Cr/6, Mo/6	19.14	Fe/3, Cr/6, Mo/6	16.111
317	S31700	Ni/2	Fe/2, Cr/3, Mo/3	25.26	Fe/3, Cr/3, Mo/4	25.03	Fe/3, Cr/6, Mo/6	19.15	Fe/3, Cr/6, Mo/6	15.82
410	S41000		Fe/2, Cr/3	25.94	Fe/3, Cr/3	18.45	Fe/3, Cr/6	16.28		
430	S43000		Fe/2, Cr/3	25.30	Fe/3, Cr/3	18.38	Fe/3, Cr/6	15.58		
446	S44600		Fe/2, Cr/3	24.22	Fe/3, Cr/3	18.28	Fe/3, Cr/6	14.46		
20CD3[a]	N08020	Ni/2	Fe/2, Cr/3, Mo/3 Cu/1	23.98	Fe/2, Cr/3, Mo/4, Cu/1	23.83	Fe/3, Cr/3, Mo/6, Cu/2	18.88	Fe/3, Cu/6, Mo/6, Cu/2	15.50

[1] See ASTM G 102, Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements.

Common Designation	UNS	Elements w/Constant Valence	Lowest		Second		Third		Fourth	
			Variable Valence	Equivalent Weight	Variable Valence	Equivalent Weight	Element/ Valence	Equivalent Weight	Element/ Valence	Equivalent Weight
Nickel Alloys										
200	N02200		Ni/2	29.36	Ni/3	19.57				
400	N04400	Ni/2	Cu/1	35.82	Cu/2	30.12				
600	N06600	Ni/2	Fe/2, Cr/3	26.41	Fe/3, Cr/3	25.44	Fe/3, Cr/6	20.73		
800	N08800	Ni/2	Fe/2, Cr/3	25.10	Fe/3, Cr/3	20.76	Fe/3, Cr/6	16.59		
825	N08825	Ni/2	Fe/2, Cr/3, Mo/3, Cu/1	25.52	Fe/3, Cr/3, Mo/4, Cu/1	25.32	Fe/3, Cr/3, Mo/6, Cu/2	21.70	Fe/3, Cr/6, Mo/6, Cu/2	17.10
B	N10001	Ni/2	Mo/3, Fe/2	30.05	Mo/4, Fe/2	27.50	Mo/6, Fe/2	23.52	Mo/6, Fe/3	23.23
C-22[b]	N06022	Ni/2	Fe/2, Cr/3, Mo/3, W/4	26.04	Fe/2, Cr/3, Mo/4, W/4	25.12	Fe/2, Cr/3, Mo/6, W/6	23.28	Fe/3, Cr/6, Mo/6, W/6	17.88
C-276	N10276	Ni/2	Fe/2, Cr/3, Mo/3, W/4	27.09	Cr/3, Mo/4	25.90	Fe/2, Cr/3, Mo/6, W/6	23.63	Fe/3, Cr/6, Mo/6 W/6	19.14
G	N06007	Ni/2	(1)	25.46	(2)	22.22	(3)	22.04	(4)	17.03
(1) = Fe/2, Cr/3, Mo/3, Cu/1, Nb/4, Mn/2			(3) = Fe/3, Cr/3, Mo/6, Cu/2, Nb/5, Mn/2							
(2) = Fe/2, Cr/3, Mo/3, Cu/2, Nb/5, Mn/2			(4) = Fe/3, Cr/6, Mo/6, Cu/2, Nb/5, Mn/4							
Carbon Steel										
			Fe/2	27.92	Fe/3	18.62				
Other Metals										
Mg	M14142	Mg/2		12.15						
Mo	R03600		Mo/3	31.98	Mo/4	23.98	Mo/6	15.99		
Ag	P07016		Ag/1	107.87	Ag/2	53.93				
Ta	R05210	Ta/5		36.19						
Sn	L13002		Sn/2	59.34	Sn/4	29.67				
Ti	R50400		Ti/2	23.95	Ti/3	15.97	Ti/4	11.98		
Zn	Z19001	Zn/2		32.68						
Zr	R60701	Zn/4		22.80						
Pb	L50045		Pb/2	103.59	Pb/4	51.80				

[a]Registered trademark Carpenter Technology.

[b]Registered trademark Haynes International.

NOTE 1—Alloying elements at concentrations below 1 % by mass were not included in the calculation, for example, they were considered part of the basis metal.

NOTE 2—Midrange values were assumed for concentrations of alloying elements.

NOTE 3—Only consistent valence groupings were used.

NOTE 4—Equation 4 in ASTM G 102 was used to make these calculations.

Values of Constants for Use in Faraday's Equation[1]

Calculation of Corrosion Rate—Faraday's Law can be used to calculate the corrosion rate, either in terms of penetration rate (*CR*) or mass loss rate (*MR*)

$$CR = K_1 \frac{i_{cor}}{\rho} EW$$

$$MR = K_2 i_{cor} EW$$

where

CR is given in mm/yr, i_{cor} in $\mu A/cm^2$,
K_1 = 3.27 10^{-3}, mm g/μA cm yr,
ρ = density in g/cm^3, (see ASTM G 1 for density values for many metals and alloys used in corrosion testing),
MR = $g/m^2 d$, and
K_2 = 8.954×10^{-3}, g $cm^2/\mu A$ m^2 d.

Other values for K_1 and K_2 for different unit systems are given in the following table.

Rate				
A				
Penetration Rate Unit (CR)	I_{cor} Unit	ρ Unit	K_1	Units of K_1[a]
mpy	$\mu A/cm^2$	g/cm^3	0.1288	mpy g/μA cm
mm/yr[b]	A/m^2[b]	kg/m^3[b]	327.2	mm kg/A m y
mm/yr[b]	$\mu A/cm^2$	g/cm^3	3.27×10^{-3}	mm g/μA cm y
B				
Mass Loss Rate Unit	I_{cor} Unit	K_2	Units of K_2[a]	
$g/m^2 d$[b]	A/m^2[b]	0.8953	g/Ad	
$mg/dm^2 d$ (mdd)	$\mu A/cm^2$	0.0895	mg $cm^2/\mu A$ dm^2 d	
$mg/dm^2 d$ (mdd)	A/m^2[b]	8.953×10^{-3}	mg m^2/A dm^2 d	

[a] EW is assumed to be dimensionless.
[b] SI unit.

[1] See ASTM G 102, Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements.

Physical Properties of Gases and Liquids

Name	Formula	Molecular Weight	Density, g/L	Melting Point, °C	Boiling Point, °C	Auto-Ignition Point °C	Explosive Limits Percent by Vol. in Air	
							Lower	Upper
Acetylene	C_2H_2	26.04	1.173	–81	–83.6 subl.	335	2.5	80.0
Air			1.2929					
Ammonia	NH_3	17.03	0.7710	–77.7	–33.4	780	16.0	77.0
Argon	Ar	39.94	1.784	–189.2	–185.7			
Butane-n	C_4H_{10}	58.12	0.601	–138	0.6	430	1.6	8.5
Butylene-n	C_4H_8	56.10	0.595	–185	–6.3		1.7	9.0
Carbon dioxide	CO_2	44.01	1.977	–57 5 atm.	–78.5 subl.			
Carbon monoxide	CO	28.01	1.250	–207	–191	650	12.5	74.2
Chlorine	Cl_2	70.91	3.214	–101	–34			
Ethane	C_2H_6	30.07	0.572	–172	–88.6	510	3.1	15.0
Ethylene	C_2H_4	28.05	0.384	–169	–103.7	543	3.0	34.0
Helium	He	4.003	0.1785	–272	–268.9			
Heptane-n	C_7H_{16}	100.20	0.684 g/cm^3	–90.6	98.4	233	1.0	6.0
Hexane-n	C_6H_{14}	86.17	0.6594 g/cm^3	–95.3	68.7	248	1.2	6.9
Hydrogen	H_2	2.016	0.0899	–259.2	–252.8	580	4.1	74.2
Hydrogen chloride	HCl	36.47	1.639	–112	–84			
Hydrogen fluoride	HF	20.01	0.921	–92.3	19.5			
Hydrogen sulfide	H_2S	34.08	1.539	–84	–62		4.3	45.5
Methane	CH_4	16.04	0.7168	–182.5	–161.5	538	5.3	13.9
Nitrogen	N_2	28.016	1.2506	–209.9	–195.8			
Octane-n	C_8H_{18}	114.23	0.7025 g/cm^3	–56.8	125.7	232	0.8	3.2
Oxygen	O_2	32.00	1.4290	–218.4	–183.0			
Pentane-n	C_5H_{12}	72.15	0.626 g/cm^3	–131	36.2	310	1.4	8.0
Propane	C_3H_8	44.09	0.501	–189	–44.5	465	2.4	9.5
Propylene	C_3H_6	42.05	0.519	–184	–48	458	2.0	11.1
Sulfur dioxide	SO_2	64.06	2.926	–75.7	–10.0			

Density of gases in g/L at 0°C and 760 mm Hg.

Density of liquids in g/cm^3 at 20°/4°C.

Physical Properties of Elements

	Symbol	Atomic Weight	Density g/cm^3 20°C	Valencies	Melting Point, °C	Crystal Structure
Aluminium	Al	29.98	2.70	3	660	1
Antimony	Sb	121.75	6.68	3/5	630	5
Argon	Ar	39.948	1.784[a]	0	-189.2	1
Arsenic	As	74.92	5.73	3/5	814	5
Barium	Ba	137.34	3.5	2	725	2
Beryllium	Be	9.01	1.85	2	1280	3
Bismuth	Bi	208.98	9.80	3/5	271	5
Boron	B	10.81	2.3	3	2300	—
Bromine	Br	79.91	3.12	1/3/5/7	-7.2	6
Cadmium	Cd	112.40	8.65	2	321	3
Calcium	Ca	40.08	1.55	2	842	1
Carbon	C	12.01	2.25	2/3/4	3550	4
Chlorine	Cl	35.45	1.56[b]	1/3/5/7	-103	7
Chromium	Cr	52.00	7.2	2/3/6	1890	2
Cobalt	Co	58.93	8.9	2/3	1495	3
Copper	Cu	63.54	8.92	1/2	1083	1
Fluorine	F	19.00	1.69[a]	1	223	—
Gold	Au	196.97	19.32	1/3	1063	1
Helium	He	4.003	0.177[a]	0	-272.2	—
Hydrogen	H	1.008	0.090[b]	1	-259.2	4
Iodine	I	126.90	4.93	1/3/5/7	113.5	6
Iron	Fe	55.85	7.87	2/3/6	1535	2
Lead	Pb	207.19	11.35	2/4	327.4	1
Lithium	Li	6.94	0.53	1	186	2
Magnesium	Mg	24.31	1.74	2	651	3
Manganese	Mn	54.94	7.2	2/3/4/6/7	1260	10
Mercury	Hg	200.59	13.55	1/2	-38.9	5
Molybdenum	Mo	95.94	10.2	2/3/4/5/6	2620	2
Nickel	Ni	58.71	8.90	2/3	1455	1
Niobium	Nb	92.91	8.55	3/5	2500	2
Nitrogen	N	14.007	1.25[a]	3/5	-209.9	4
Oxygen	O	15.9994	1.429[a]	2	-218.4	10
Phosphorus	P	30.98	1.82	3/5	44.1	10
Platinum	Pt	195.09	21.37	2/4	1773	1
Potassium	K	39.10	0.87	1	62.3	2
Rhodium	Rh	102.91	12.5	1/2/3/4	1966	1
Selenium	Se	78.96	4.8	2/4/6	220	4
Silicon	Si	28.09	2.42	4	1420	8
Silver	Ag	107.87	10.50	1	960.5	1
Sodium	Na	22.99	0.97	1	97.5	2
Sulfur	S	32.06	2.07	2/4/6	119	9
Tantalum	Ta	180.95	16.6	3/5	2996	2
Tin	Sn	118.69	7.31	2/4	231.9	7
Titanium	Ti	47.90	4.5	2/3/4	1800	3
Tungsten	W	183.85	19.3	2/4/5/6	3370	2
Vandium	V	50.94	5.96	2/3/4/5	1710	2
Zinc	Zn	65.73	7.14	2	419.5	3
Zirconium	Zr	91.22	6.4	4	1857	3

[a] g/L (0°C and 760 mm Hg)

[b] Liquid at boiling point -37°C

[c] Crystal structures:

1 Face-centered cubic
2 Body-centered cubic
3 Close packed hexagonal
4 Hexagonal
5 Rhombohedral
6 Orthorhombic
7 Tetragonal
8 Diamond cubic
9 Face-centered orthorhombic
10 Cubic (complex)

Densities for a Variety of Metals and Alloys[1]

UNS Number	Alloy	Density, g/cm^3
	Aluminum Alloys	
A91100	1100	2.71
A91199	1199	2.70
A92024	2024	2.78
A92219	2219	2.84
A93003	3003	2.73
A93004	3004	2.72
A95005	5005	2.70
A95050	5050	2.69
A95052	5052	2.68
A95083	5083	2.66
A95086	5086	2.66
A95154	5154	2.66
A95357	5357	2.69
A95454	5454	2.69
A95456	5456	2.66
A96061	6061	2.70
*	6062	2.70
A96070	6070	2.71
A96101	6101	2.70
A97075	7075	2.81
A97079	7079	2.75
A97178	7178	2.83
	Stainless Steels	
S20100	Type 201	7.94
S20200	Type 202	7.94
S20200	Type 302	7.94
S30400	Type 304	7.94
S30403	Type 304L	7.94
S30900	Type 309	7.94
S31000	Type 310	7.98
S31100	Type 311	7.98
S31600	Type 316	7.98
S31603	Type 316L	7.98
S31700	Type 317	7.98
S32100	Type 321	7.94
S32900	Type 329	7.98
N06330	Type 330	7.98
S34700	Type 347	8.03
S41000	Type 410	7.70
S43000	Type 430	7.72
S44600	Type 446	7.65
S50200	Type 502	7.82
	Other Ferrous Metals	
FIXXXX	Gray cast iron	7.20
GXXXXX-KXXXXX	Carbon steel	7.86
*	Silicon iron	7.00
KXXXXX	Low alloy steels	7.85

[1] See ASTM G 1, Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens.

UNS Number	Alloy	Density, g/cm^3
	Copper Alloys	
C38600	Copper	8.94
C23000	Red brass 230	8.75
C26000	Cartridge brass 260	8.52
C28000	Muntz metal 280	8.39
*	Admiralty 442	8.52
C44300	Admiralty 443	8.52
C44400	Admiralty 444	8.52
C44500	Admiralty 445	8.52
C68700	Aluminum brass 687	8.33
C22000	Commercial bronze 220	8.80
C60800	Aluminum bronze, 5 % 608	8.16
*	Aluminum bronze, 8 % 612	7.78
*	Composition M	8.45
*	Composition G	8.77
C51000	Phosphor bronze, 5 % 510	8.86
C52400	Phosphor bronze, 10 % 524	8.77
*	85-5-5-5	8.80
C65500	Silicon bronze 655	8.52
C70600	Copper nickel 706	8.94
C71000	Copper nickel 710	8.94
C71500	Copper nickel 715	8.94
C75200	Nickel silver 752	8.75
	Lead	
L53305-53405	Antimonial	10.80
L5XXXX	Chemical	11.33
	Nickel Alloys	
N02200	Nickel 200	8.89
N04400	Nickel copper 400	8.84
N06600	Nickel chromium iron alloy 600	8.51
N06625	Nickel chromium molybedenum alloy 625	8.14
N08825	Iron nickel chromium alloy 825	8.14
N08020	Iron nickel chromium alloy 20 Cb-3	8.08
*	Iron nickel chromium cast alloy 20	8.02
N10665	Nickel molybedenum alloy B2	9.2
N10276	Nickel chromium molybdenum alloy C-276	8.8
N06985	Nickel chromium molybdenum alloy G-3	8.3
	Other Metals	
MIXXXX	Magnesium	1.74
R03600	Molybdenum	10.22
P04980	Platinum	21.45
P07016	Silver	10.49
R05200	Tantalum	16.60
L13002	Tin	7.30
R50250	Titanium	4.54
Z13001	Zinc	7.13
R60001	Zirconium	6.53

NOTES—All UNS numbers that include the letter X indicate a series of numbers under one category. An asterisk(*) indicates that a UNS number not available.

Density of Materials

Material	Density (g/cm^3)	Density ($lb/in.^3$)
Iridium	22.65	0.82
Osmium	22.61	0.82
Platinum	21.45	0.77
Rhenium	21.00	0.76
Tungsten	19.40	0.70
Gold	19.30	0.70
Uranium	19.07	0.69
Tungsten carbide	17.20	0.62
Tantalum	16.60	0.60
Tantalum carbide (TaC)	14.53	0.52
Hafnium	13.10	0.47
Ruthenium	12.45	0.45
Rhodium	12.41	0.45
Palladium	12.02	0.43
Thallium	11.85	0.43
Thorium	11.50	0.42
Lead	11.34	0.41
Silver	10.49	0.38
Molybdenum	10.20	0.37
Bismuth	9.80	0.35
Thulium	9.31	0.34
Cast high leaded tin bronze	9.29	0.34
Nickel-moly (Hastelloy B-2)	9.20	0.33
Copper	8.96	0.32
Nickel	8.90	0.32
Copper nickel (64Cu-14Ni-227n)	8.85	0.32
Cobalt	8.85	0.32
Nickel silver	8.70	0.31
Brass (61.5Cu-3Pb-35.5Zn)	8.70	0.31
Bronze (57Cu, 40Zn, 39Pb)	8.70	0.31
Cadmium	8.65	0.31
Niobium (Columbium)	8.57	0.31
Nickel chromimum cobalt alloy	8.21	0.30
Nickel-chromium (Inconel 718)	8.20	0.30
Copper zinc alloy	8.19	0.30
Maraging steel	8.02	0.29
Austenitic stainless steel	8.00	0.29
Iron-nickel (Invar)	8.00	0.29
Iron	7.87	0.28
Nickel iron superalloy	7.86	0.28
Chromium steel	7.83	0.28
Nonresulfurized carbon steel	7.83	0.28
Stainless steel (17Cr-4Ni)	7.81	0.28
Hot work tool steel	7.75	0.28
Aluminum bronze	7.64	0.28
Babbitt	7.50	0.27
Samarium	7.49	0.27
Manganese	7.43	0.27
Indium	7.31	0.26
Niobium nitride	7.30	0.26
Tin	7.30	0.26
Cerium dioxide	7.28	0.26
Austempered ductile iron	7.20	0.26
Pewter (Sn,Sb,Cu)	7.20	0.26
Chromium	7.19	0.26
Zinc	7.13	0.26
Neodymium	7.00	0.25
Praseodymium	6.77	0.24
Cerium	6.77	0.24
Chromium carbide	6.70	0.24
Antimony	6.65	0.24
Zirconium	6.49	0.23
Lanthanum	6.15	0.22
Vanadium	6.11	0.22

Material	Density (g/cm^3)	Density ($lb/in.^3$)
Nickel aluminide (NiAl)	6.05	0.22
Gallium	5.91	0.21
Zirconia (partially stabilized)	5.70	0.21
Germanium	5.32	0.19
Titanium nitride	5.29	0.19
Titanium carbide	4.94	0.18
Titanium diboride	4.52	0.16
Titanium	4.51	0.16
Ti-6Al-4V	4.50	0.16
Titanium dioxide	4.25	0.15
Aluminum oxide	3.98	0.14
Spinel ($MgO \cdot Al_2O_3$)	3.57	0.13
Aluminum nitride	3.26	0.12
Sialon	3.20	0.12
Silicon nitride	3.19	0.12
Mullite($3Al_2O_3 \cdot 2SiO_2$)	3.16	0.11
Silicon carbide	3.10	0.11
Hydroxyapatite	3.10	0.00
Aluminum carbide	2.99	0.11
Wollastonite	2.90	0.10
Aluminum copper alloy	2.84	0.10
Aluminum zinc alloy	2.78	0.10
Aluminum	2.70	0.10
Cordierite	2.65	0.10
E-glass fiber	2.62	0.10
Pyrex glass	2.52	0.09
Boron carbide	2.52	0.09
Boron	2.40	0.09
Silicon	2.33	0.08
PTFE (polytetrafluoroethylene)	2.30	0.08
Graphite	2.26	0.08
Boron nitride	2.25	0.08
Sulfur	2.07	0.07
Unsaturated polyester	2.00	0.07
Polyimide thermoset	2.00	0.07
Phenolic resin	1.99	0.07
Beryllium	1.85	0.07
Phosphorus	1.83	0.07
Carbon fiber	1.74	0.06
Magnesium	1.74	0.06
PPS (polyphenylene sulfide)	1.67	0.06
Nylon 6	1.64	0.06
Acetal resin	1.57	0.06
Epoxy resin	1.56	0.06
Calcium	1.55	0.06
Rubidium	1.53	0.06
Polycarbonate	1.53	0.06
Aramid fiber	1.45	0.05
Aromatic polyamide	1.44	0.05
Bismaleimide resin	1.36	0.05
Silicone	1.35	0.05
PEEK (polyetheretherketone)	1.32	0.05
Cellulose acetate	1.30	0.05
Human Bone	1.30	0.05
Polyurethane	1.27	0.05
ABS (acrylonitrile butadiene styrene)	1.26	0.05
Polysulfone	1.24	0.04
Acrylic	1.19	0.04
Polypropylene	1.05	0.04
Sodium	0.97	0.04
PE (polyethylene)	0.95	0.03
UHMWPE (ultrahigh molecular weight PE)	0.93	0.03
Potassium	0.86	0.03
Lithium	0.53	0.19

Source: GEM 2001, p. 35, ASM 2000.

Coefficients of Thermal Expansion of Common Alloys[1]

UNS	Common Name	in/in/°F x 10^{-6}	mm/mm/°C x 10^{-6}	Range, °C
A24430	Cast Al B443.0	12.3	22	20–100
A91100	Al 1100	13.1	24	20–100
A95052	Al 5052	13.2	24	20–100
C11000	ETP Copper	9.4	16.9	20–100
C23000	Red Brass	10.4	18.7	20–300
C28000	Muntx Metal	11.6	21	20–300
C44300	Admiralty Brass, As	11.2	20	20–300
C61400	Aluminum Bronze D	9.0	18.2	20–300
C70600	90-10 Copper-Nickel	9.5	17.1	20–300
C71500	70-30 Copper-Nickel	9.0	16.2	20–300
C83600	Ounce Metal	10.2	18.4	0–100
F10006	Gray Cast Iron	6.7	12.1	0–100
G10200	Carbon Steel	6.7	12.1	0–100
J94224	HK Cast SS	9.4	16.9	20–540
L13002	Tin	12.8	23	0–100
L51120	Chemical Lead	16.4	30	0–100
L55030	50/50 Solder	13.1	24	0–100
M11311	Mg AZ31B	14.5	26	20–100
M13310	Mg HK31A	14.5	26	20–100
N02200	Nickel 200	7.4	13.3	20–90
N04400	400 Alloy	7.7	13.9	20–90
N06600	600 Alloy	7.4	13.3	20–90
N10276	C-276 Alloy	6.3	11.3	20–90
N10665	B-2 Alloy	5.6	10.1	20–90
R03600	Molybdenum	2.7	4.9	20–100
R05200	Tantalum	3.6	6.5	20–100
R50250	Titanium, Gr 1	4.8	8.6	0–100
R56400	Titanium, Gr 5	4.9	8.8	0–100
R60702	Zr 702	2.9	5.2	0–100
S30400	304 SS	9.8	17.3	0–100
S31000	310 SS	8.0	14.4	0–100
S41000	410 SS	6.1	11.0	0–100
S44600	446 SS	5.8	10.4	0–100
S50200	5Cr-0.5Mo Steel	7.3	13.1	20–540
Z13001	Zinc	18	32	0–100

[1]See *NACE Corrosion Engineers Reference Book, Third Edition*, R. Baboian, Ed., NACE International, 2002, p. 291.

Physical Properties of Water

Temperature, t °C	Density[1], d g/mL	Specific Volume[1], v mL/g	Vapor Pressure[2], p mm Hg*	Viscosity[3], η Centipose	Dielectric Constant[4], ε
0**	0.99987	1.00013	4.580	1.787	87.74
5	.99999	1.00001	6.538	1.517	85.76
10	.99973	1.00027	9.203	1.306	83.83
15	.99913	1.00087	12.782	1.138	81.95
18	.99862	1.00138	15.471	1.053	80.84
20	.99823	1.00177	17.529	1.002	80.10
25	.99707	1.00293	23.753	0.8903	78.30
30	.99567	1.00434	31.824	.7974	76.55
35	.99406	1.00598	42.180	.7194	74.83
38	.99299	1.00706	49.702	.6783	73.82
40	.99224	1.00782	55.338	.6531	73.15
45	.99025	1.00985	71.90	.5963	71.51
50	.98807	1.01207	92.56	.5471	69.91
55	.98573	1.01448	118.11	.5044	68.34
60	.98324	1.01705	149.47	.4669	66.81
65	.98059	1.01979	187.65	.4338	65.32
70	.97781	1.02270	233.81	.4044	63.86
75	.97489	1.02576	289.22	.3782	62.43
80	.97183	1.02899	355.31	.3547	61.03
85	.96865	1.03237	433.64	.3340	59.66
90	.96534	1.03590	525.92	.3149	58.32
95	.96192	1.03959	634.04	.2976	57.01
100***	.95838	1.04343	760.00	.2822	55.72

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2 – F. G. Keyes, J. Chem. Phys., 15, 602 (1947).

3 – J. F. Swindells, J. R. Coe, and T. B. Godfrey, J. Research Nat. Bur. Standards, *48*, 1 (1952); R. C. Hardy and R. L. Cottington, *ibid*, *42*, 573 (1949); J. R. Coe and T. B. Godfrey, J. App. Phys., *15*, 625 (1944).

4 – C. G. Malmberg and A. A. Maryott, J. Research Nat. Bur. Standards, *56*, 1 (1956).

* – 760 mm Hg = 1 atmosphere = 1,013,250 dyn cm^{-2} = 101,325 newtons m^{-2} on the Système International d'Unites, adopted in a resolution, 11th General Conference on Weights and Measures, Paris, October 1960, the international unit of pressure is the Newton per square meter.

** – The freezing point is zero degrees Celsius, exactly; the triple point of water is 0.001°C or 273.16°K.

*** – The boiling point.

Dew Point of Moist Air[1]

The temperature drop required for condensation to occur at a specified air temperature and relative humidity is given in the table below. The temperature drops are mean values for the indicated air temperature ranges.

	Air Temperature °C			Air Temperature °F	
RH %	0–20	20–35	RH %	32–68	68–95
55	9	10	55	16	18
60	7	9	60	13	15
65	6	7	65	11	13
70	5	6	70	9	11
75	4	5	75	8	9
80	3	4	80	6	7
85	2	3	85	4	5
90	1.6	1.8	90	3	3
92	1.2	1.4	92	2.2	2.5
95	0.8	0.9	95	1.4	1.6
98	0.3	0.3	98	0.5	0.5

Example: At 30°C (86°F) and 80 % RH, a temperature drop of 4°C (7°F) would result in condensation.

Dew point temperatures of moist air as a function of air temperature and relative humidity are tabulated on the following four pages.

[1] See *NACE Corrosion Engineers Reference Book, Third Edition*, R. Baboian, Ed., NACE International, 2002, pp. 69–73.

Dew Point of Moist Air °C[1]

	Air Temperature °C												
RH %	0	2	4	6	8	10	12	14	16	18	20	22	24
1	–50	–49	–47	–46	–45	–44	–42	–41	–40	–39	–38	–36	–35
3	–40	–39	–37	–36	–34	–33	–32	–30	–29	–28	–26	–25	–24
5	–35	–34	–32	–31	–29	–28	–26	–25	–24	–22	–21	–19	–24
7	–32	–30	–29	–27	–26	–24	–23	–21	–20	–18	–17	–15	–14
9	–29	–27	–26	–24	–23	–21	–20	–18	–17	–15	–14	–12	–11
11	–27	–25	–24	–22	–21	–19	–17	–16	–14	–13	–11	–10	–8
13	–25	–23	–22	–20	–19	–17	–15	–14	–12	–11	–9	–8	–6
15	–23	–22	–20	–19	–17	–15	–14	–12	–11	–9	–7	–6	–4
17	–22	–20	–19	–17	–15	–14	–12	–11	–9	–7	–6	–4	–2
19	–21	–19	–17	–16	–14	–12	–11	–9	–8	–6	–4	–3	–1
21	–20	–18	–16	–15	–13	–11	–10	–8	–6	–5	–3	–1	0
23	–19	–17	–15	–14	–12	–10	–8	–7	–5	–3	–2	0	2
25	–18	–16	–14	–13	–11	–9	–7	–6	–4	–2	–1	1	3
27	–17	–15	–13	–12	–10	–8	–6	–5	–3	–1	1	2	4
29	–16	–14	–12	–11	–9	–7	–5	–4	–2	0	2	3	5
31	–15	–13	–12	–10	–8	–6	–5	–3	–1	1	2	4	6
33	–14	–13	–11	–9	–7	–6	–4	–2	0	2	3	5	7
35	–14	–12	–10	–8	–7	–5	–3	–1	1	2	4	6	8
37	–13	–11	–9	–8	–6	–4	–2	0	1	3	5	7	9
39	–12	–10	–9	–7	–5	–3	–1	0	2	4	6	8	9
41	–12	–10	–8	–6	–4	–3	–1	1	3	5	6	8	10
43	–11	–9	–7	–6	–4	–2	0	2	4	5	7	9	11
45	–11	–9	–7	–5	–3	–1	1	2	4	6	8	10	11
47	–10	–8	–6	–5	–3	–1	1	3	5	7	8	10	12
49	–9	–8	–6	–4	–2	0	2	4	5	7	9	11	13
51	–9	–7	–5	–3	–1	0	2	4	6	8	10	12	13
53	–8	–7	–5	–3	–1	1	3	5	7	8	10	12	14
55	–8	–6	–4	–2	–1	1	3	5	7	9	11	13	14
57	–7	–6	–4	–2	0	2	4	6	8	9	11	13	15
59	–7	–5	–3	–1	1	2	4	6	8	10	12	14	16
61	–7	–5	–3	–1	1	3	5	7	9	11	12	14	16
63	–6	–4	–2	0	2	3	5	7	9	11	13	15	17
65	–6	–4	–2	0	2	4	6	8	10	11	13	15	17
67	–5	–3	–2	0	2	4	6	8	10	12	14	16	18
69	–5	–3	–1	1	3	5	7	8	10	12	14	16	18
71	–5	–3	–1	1	3	5	7	9	11	13	15	17	19
73	–4	–2	0	2	4	6	7	9	11	13	15	17	19
75	–4	–2	0	2	4	6	8	10	12	14	15	17	19
77	–4	–2	0	2	4	6	8	10	12	14	16	18	20
79	–3	–1	1	3	5	7	8	10	12	14	16	18	20
81	–3	–1	1	3	5	7	9	11	13	15	17	19	21
83	–3	–1	1	3	5	7	9	11	13	15	17	19	21
85	–2	0	2	4	6	8	10	12	14	16	18	19	21
87	–2	0	2	4	6	8	10	12	14	16	18	20	22
89	–2	0	2	4	6	8	10	12	14	16	18	20	22
91	–1	1	3	5	7	9	11	13	15	17	19	21	23
93	–1	1	3	5	7	9	11	13	15	17	19	21	23
95	–1	1	3	5	7	9	11	13	15	17	19	21	23
97	0	2	4	6	8	10	12	14	16	18	20	22	24
99	0	2	4	6	8	10	12	14	16	18	20	22	24

Continued on Next Page

[1] See *NACE Corrosion Engineers Reference Book, Third Edition*, R. Baboian, Ed., NACE International, 2002.

Dew Point of Moist Air °C[1] (Cont.)

	Air Temperature °C												
RH %	26	28	30	32	34	36	38	40	42	44	46	48	50
1	–34	–33	–32	–30	–29	–28	–27	–26	–25	–24	–22	–21	–20
3	–22	–21	–20	–18	–17	–16	–14	–13	–12	–11	–9	–8	–7
5	–16	–15	–14	–12	–11	–10	–8	–7	–5	–4	–3	–1	0
7	–12	–11	–9	–8	–7	–5	–4	–2	–1	1	2	4	5
9	–9	–8	–8	–5	–3	–2	0	1	3	4	6	7	9
11	–7	–5	–4	–2	–1	1	3	4	6	7	9	10	12
13	–4	–3	–1	0	2	3	5	6	8	10	11	13	14
15	–3	–1	1	2	4	5	7	9	10	12	13	15	16
17	–1	1	2	4	6	7	9	10	12	14	15	17	18
19	1	2	4	6	7	9	10	12	14	15	17	19	20
21	2	4	5	7	9	10	12	14	15	17	19	20	22
23	3	5	7	8	10	12	13	15	17	18	20	22	23
25	5	6	8	10	11	13	15	16	18	20	21	23	25
27	6	7	9	11	12	14	16	18	19	21	23	24	26
29	7	8	10	12	14	15	17	19	20	22	24	25	27
31	8	9	11	13	15	16	18	20	21	23	25	27	28
33	9	10	12	14	16	17	19	21	22	24	26	28	29
35	9	11	13	15	16	18	20	22	23	25	27	29	30
37	10	12	14	16	17	19	21	23	24	26	28	30	31
39	11	13	15	16	18	20	22	24	25	27	29	31	32
41	12	14	15	17	19	21	23	24	26	28	30	31	33
43	13	14	16	18	20	22	23	25	27	29	31	32	34
45	13	15	17	19	20	22	24	26	28	29	31	33	35
47	14	16	17	19	21	23	25	27	28	30	32	34	36
49	15	16	18	20	22	24	26	27	29	31	33	35	36
51	15	17	19	21	23	24	26	28	30	32	34	35	37
53	16	18	20	21	23	25	27	29	31	32	34	36	38
55	16	18	20	22	24	26	27	29	31	33	35	37	38
57	17	19	21	23	24	26	28	30	32	34	36	37	39
59	17	19	21	23	25	27	29	30	32	34	36	38	40
61	18	20	22	24	26	27	29	31	33	35	37	39	41
63	19	20	22	24	26	28	30	32	34	35	37	39	41
65	19	21	23	25	27	28	30	32	34	36	38	40	42
67	19	21	23	25	27	29	31	33	35	37	38	40	42
69	20	22	24	26	28	30	31	33	35	37	39	41	43
71	20	22	24	26	28	30	32	34	36	38	40	42	43
73	21	23	25	27	29	31	32	34	36	38	40	42	44
75	21	23	25	27	29	31	33	35	37	39	41	42	44
77	22	24	26	28	29	31	33	35	37	39	41	43	45
79	22	24	26	28	30	32	34	36	38	40	41	43	45
81	23	25	26	28	30	32	34	36	38	40	42	44	46
83	23	25	27	29	31	33	35	37	39	40	42	44	46
85	23	25	27	29	31	33	35	37	39	41	43	45	47
87	24	26	28	30	32	34	36	37	39	41	43	45	47
89	24	26	28	30	32	34	36	38	40	42	44	46	48
91	25	27	29	31	32	34	36	38	40	42	44	46	48
93	25	27	29	31	33	35	37	39	41	43	45	47	49
95	25	27	29	31	33	35	37	39	41	43	45	47	49
97	26	28	30	32	34	36	38	40	42	44	46	48	50
99	26	28	30	32	34	36	38	40	42	44	46	48	50

Dew Point of Moist Air °F

Air Temperature °F

RH %	32	35	38	41	44	47	50	53	56	59	62	65	68	71	74
1	-57	-56	-54	-52	-50	-48	-46	-45	-43	-41	-39	-37	-36	-34	-32
3	-40	-38	-36	-34	-32	-30	-28	-25	-23	-21	-19	-17	-15	-13	-11
5	-31	-29	-27	-25	-22	-20	-18	-16	-14	-12	-9	-7	-5	-3	-1
7	-25	-23	-20	-18	-16	-14	-11	-9	-7	-5	-2	0	2	4	6
9	-20	-18	-15	-13	-11	-9	-6	-4	-2	1	3	5	7	10	12
11	-16	-14	-12	-9	-7	-5	-2	0	2	5	7	9	12	14	16
13	-13	-11	-8	-6	-3	-1	1	4	6	8	11	13	16	18	20
15	-10	-8	-5	-3	0	2	4	7	9	12	14	16	19	21	24
17	-8	-5	-3	0	2	5	7	10	12	15	17	19	22	24	27
19	-5	-3	0	2	5	7	10	12	15	17	19	22	24	27	29
21	-3	-1	2	4	7	9	12	14	17	19	22	24	27	29	32
23	-1	1	4	6	9	11	14	16	19	21	24	26	29	31	34
25	0	3	5	8	11	13	16	18	21	23	26	28	31	33	36
27	2	5	7	10	12	15	17	20	23	25	28	30	33	35	38
29	4	6	9	11	14	17	19	22	24	27	29	32	35	37	40
31	5	8	10	13	16	18	21	23	26	29	31	34	36	39	42
33	6	9	12	14	17	20	22	25	27	30	33	35	38	41	43
35	8	10	13	16	18	21	24	26	29	31	34	37	39	42	45
37	9	12	14	17	20	22	25	28	30	33	36	38	41	44	46
39	10	13	15	18	21	23	26	29	32	34	37	40	42	45	48
41	11	14	17	19	22	25	27	30	33	35	38	41	44	46	49
43	12	15	18	20	23	26	29	31	34	37	39	42	45	48	50
45	13	16	19	21	24	27	29	32	35	38	40	43	46	49	51
47	14	17	20	22	25	28	31	33	36	39	42	44	47	50	52
49	15	18	21	24	26	29	32	35	37	40	43	46	48	51	54
51	16	19	22	24	27	30	33	36	38	41	44	47	49	52	55
53	17	20	23	25	28	31	34	37	39	42	45	48	50	53	56
55	18	21	23	26	29	32	35	37	40	43	46	48	51	54	57
57	19	21	24	27	30	33	35	38	41	44	47	50	52	55	58
59	19	22	25	28	31	33	36	39	42	45	48	50	53	56	59
61	20	23	26	29	32	34	37	40	43	46	49	51	54	57	60
63	21	24	27	29	32	35	38	41	44	47	49	52	55	58	61
65	22	25	27	30	33	36	39	42	44	47	50	53	56	59	62
67	22	25	28	31	34	37	40	42	45	48	51	54	57	60	62
69	23	26	29	32	35	37	40	43	46	49	52	55	58	60	63
71	24	27	30	32	35	38	41	44	47	50	53	55	58	61	64
73	24	27	30	33	36	39	42	45	48	51	53	56	59	62	65
75	25	28	31	34	37	39	42	45	48	51	54	57	60	63	66
77	26	29	32	34	37	40	43	46	49	52	55	58	61	64	66
79	26	29	32	35	38	41	44	47	50	52	55	58	61	64	67
81	27	30	33	36	39	42	44	47	50	53	56	59	62	65	68
83	27	30	33	36	39	42	45	48	51	54	57	60	63	66	68
85	28	31	34	37	40	43	46	49	52	55	58	60	64	66	69
87	29	32	34	37	40	43	46	49	52	55	58	61	64	67	70
89	29	32	35	38	41	44	47	50	53	56	59	62	65	68	71
91	30	33	36	39	42	45	48	51	54	56	60	62	65	68	71
93	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72
95	31	34	37	40	43	46	49	52	55	58	61	64	67	70	73
97	31	34	37	40	43	46	49	52	55	58	61	64	67	70	73
99	32	35	38	41	44	47	50	53	56	59	62	65	68	71	74

Continued on Next Page

[1] See *NACE Corrosion Engineers Reference Book, Third Edition,* R. Baboian, Ed., NACE International, 2002.

Dew Point of Moist Air °F (Cont.)

	Air Temperature °F															
RH %	77	80	83	86	89	92	95	98	101	104	107	110	113	116	119	122
1	–30	–28	–27	–25	–23	–21	–20	–18	–16	–14	–13	–11	–9	–7	–6	–4
3	–9	–7	–5	–3	–1	1	2	4	6	8	10	12	14	16	18	20
5	1	3	5	8	10	12	14	16	16	20	22	24	26	28	30	32
7	8	11	13	15	17	19	22	24	26	28	30	32	35	37	39	41
9	14	16	19	21	23	25	28	30	32	34	36	39	41	43	45	47
11	19	21	23	26	28	30	32	35	37	39	41	44	46	48	50	53
13	23	25	27	30	32	34	37	39	41	44	46	48	51	53	55	57
15	26	28	31	33	35	38	40	43	45	47	50	52	54	57	59	61
17	29	31	34	36	39	41	44	46	48	51	53	55	58	60	63	65
19	32	34	37	39	42	44	46	49	51	54	56	59	61	63	66	68
21	34	37	39	42	44	47	49	52	54	56	59	61	64	66	69	71
23	37	39	42	44	47	49	51	54	56	59	61	64	66	69	71	74
25	38	41	44	46	49	51	54	56	59	61	64	66	69	71	74	76
27	41	43	46	48	51	53	56	58	61	64	66	68	71	74	76	79
29	42	45	48	50	53	55	58	60	63	65	68	71	73	76	78	81
31	44	47	49	52	55	57	60	62	65	67	70	73	75	78	80	83
33	46	48	51	54	56	59	61	64	67	69	72	74	77	80	82	85
35	47	50	53	55	58	60	63	66	68	71	74	76	79	81	84	87
37	49	52	54	57	60	62	65	67	70	73	75	78	81	83	86	89
39	50	53	56	58	61	64	66	69	72	74	77	80	82	85	87	90
41	52	54	57	60	62	65	68	70	73	76	78	81	84	86	89	92
43	53	56	58	61	64	68	69	72	75	77	80	83	85	88	91	93
45	54	57	60	62	65	68	70	73	76	78	81	84	87	89	92	95
47	55	58	61	63	66	69	72	74	77	80	82	85	88	91	93	96
49	56	59	62	65	68	70	73	76	78	81	84	87	89	92	95	98
51	58	60	63	66	69	71	74	77	80	82	85	88	91	93	96	99
53	59	62	64	67	70	73	75	78	81	84	86	89	92	95	97	100
55	60	62	65	68	71	73	76	79	82	85	87	90	93	96	98	101
57	61	64	66	69	72	75	78	80	83	86	89	91	94	97	100	103
59	62	64	67	70	73	76	78	81	84	87	90	92	95	98	101	104
61	63	66	68	71	74	77	80	82	85	88	91	94	96	99	102	105
63	64	66	69	72	75	78	81	83	86	89	92	95	98	100	103	106
65	64	67	70	73	76	79	82	84	87	90	93	96	98	101	104	107
67	65	68	71	74	77	80	82	85	88	91	94	97	100	102	105	108
69	66	69	72	75	78	80	83	86	89	92	95	98	100	103	106	109
71	67	70	73	76	79	81	84	87	90	93	96	99	101	104	107	110
73	68	71	74	76	79	82	85	88	91	94	97	100	102	105	108	111
75	69	71	74	77	80	83	86	89	92	94	97	100	103	106	109	112
77	69	72	75	78	81	84	87	90	93	96	98	101	104	107	110	113
79	70	73	76	79	82	84	87	90	93	96	99	102	105	108	111	114
81	71	74	77	80	82	85	88	91	94	97	100	103	106	109	112	115
83	71	74	77	80	83	86	89	92	95	98	101	104	107	109	112	115
85	72	75	78	81	84	87	90	93	96	99	102	105	108	110	113	116
87	73	76	79	82	85	88	91	94	96	99	102	105	108	111	114	117
89	73	76	79	82	85	88	91	94	97	100	103	106	109	112	115	118
91	74	77	80	83	86	89	92	95	98	101	104	107	110	113	116	119
93	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120
95	76	79	82	85	87	90	93	96	99	102	105	108	111	114	117	120
97	76	79	82	85	88	91	94	97	100	103	106	109	112	115	118	121
99	77	80	83	86	89	92	95	98	101	104	107	110	113	116	119	122

Chemical Cleaning Procedures for Removal of Corrosion Products[1]

Designation	Material	Solution	Time	Temperature	Remarks
C.1.1	Aluminum and Aluminum Alloys	50 mL phosphoric acid (H_3PO_4, sp gr 1.69) 20 g chromium trioxide (CrO_3) Reagent water to make 1000 mL	5 to 10 min	90°C to Boiling	If corrosion product films remain, rinse, then follow with nitric acid procedure (C.1.2).
C.1.2		Nitric acid (HNO_3, sp gr 1.42)	1 to 5 min	20 to 25°C	Remove extraneous deposits and bulky corrosion products to avoid reactions that may result in excessive removal of base metal.
C.2.1	Copper and Copper Alloys	500 mL hydrochloric acid (HCl, sp gr 1.19) Reagent water to make 1000 mL	1 to 3 min	20 to 25°C	Deaeration of solution with purified nitrogen will minimize base metal removal.
C.2.2		4.9 g sodium cyanide (NaCN) Reagent water to make 1000 mL	1 to 3 min	20 to 25°C	Removes copper sulfide corrosion products that may not be removed by hydrochloric acid treatment (C.2.1).
C.2.3		100 mL sulfuric acid (H_2SO_4, sp gr 1.84) Reagent water to make 1000 mL	1 to 3 min	20 to 25°C	Remove bulky corrosion products before treatment to minimize copper redeposition on specimen surface.
C.2.4		120 mL sulfuric acid (H_2SO_4, sp gr 1.84) 30 g sodium dichromate ($Na_2Cr_2O_7 \cdot 2H_2O$) Reagent water to make 1000 mL	5 to 10 s	20 to 25°C	Removes redeposited copper resulting from sulfuric acid treatment.
C.2.5		54 mL sulfuric acid (H_2SO_4, sp gr 1.84) Reagent water to make 1000 mL	30 to 60 min	40 to 50°C	Deaerate solution with nitrogen. Brushing of test specimens to remove corrosion products followed by re-immersion for 3 to 4 s is recommended.
C.3.1	Iron and Steel	1000 mL hydrochloric acid (HCl, sp gr 1.19) 20 g antimony trioxide (Sb_2O_3) 50 g stannous chloride ($SnCl_2$)	1 to 25 min	20 to 25°C	Solution should be vigorously stirred or specimen should be brushed. Longer times may be required in certain instances.

[1] See ASTM G1, Standard Practice For Preparing, Cleaning, and Evaluating Corrosion Test Specimens.

Designation	Material	Solution	Time	Temperature	Remarks
C.3.2		50 g sodium hydroxide (NaOH) 200 g granulated zinc or zinc chips Reagent water to make 1000 mL	30 to 40 min	80 to 90°C	Caution should be exercised in the use of any zinc dust since spontaneous ignition upon exposure to air can occur.
C.3.3		200 g sodium hydroxide (NaOH) 20 g granulated zinc or zinc chips Reagent water to make 1000 mL	30 to 40 min	80 to 90°C	Caution should be exercised in the use of any zinc dust since spontaneous ignition upon exposure to air can occur.
C.3.4		200 g diammonium citrate ($(NH_4)_2HC_6H_5O_7$) Reagent water to make 1000 mL	20 min	75 to 90°C	Depending upon the composition of the corrosion product, attack of base metal may occur.
C.3.5		500 mL hydrochloric acid (HCl, sp gr 1.19) 3.5 g hexamethylene tetramine Reagent water to make 1000 mL	10 min	20 to 25°C	Longer times may be required in certain instances.
C.3.6		Molten caustic soda (NaOH) with 1.5–2.0 % sodium hydride (NaH)	1 to 20 min	370°C	For details refer to Technical Information Bulletin SP29-370, "DuPont Sodium Hydride Descaling Process Operating Instructions."
C.4.1	Lead and Lead Alloys	10 mL acetic acid (CH_3COOH) Reagent water to make 1000 mL	5 min	Boiling	...
C.4.2		50 g ammonium acetate (CH_3COONH_4) Reagent water to make 1000 mL	10 min	60 to 70°C	...
C.4.3		250 g ammonium acetate (CH_3COONH_4) Reagent water to make 1000 mL	5 min	60 to 70°C	...
C.5.1	Magnesium and Magnesium Alloys	150 g chromium trioxide (CrO_3) 10 g silver chromate (Ag_2CrO_4) Reagent water to make 1000 mL	1 min	Boiling	The silver salt is present to precipitate chloride.
C.5.2		200 g chromium trioxide (CrO_3) 10 g silver nitrate ($AgNO_3$) 20 g barium nitrate ($Ba(NO_3)_2$) Reagent water to make 1000 mL	1 min	20 to 25°C	The barium salt is present to precipitate sulfate.
C.6.1	Nickel and Nickel Alloys	150 mL hydrochloric acid (HCl, sp gr 1.19) Reagent water to make 1000 mL	1 to 3 min	20 to 25°C	...
C.6.2		100 mL sulfuric acid (H_2SO_4, sp gr 1.84) Reagent water to make 1000 mL	1 to 3 min	20 to 25°C	...
C.7.1	Stainless Steels	100 mL nitric acid (HNO_3, sp gr 1.42) Reagent water to make 1000 mL	20 min	60°C	...
C.7.2		150 g diammonium citrate ($(NH_4)_2HC_6H_5O_7$) Reagent water to make 1000 mL	10 to 60 min	70°C	...
C.7.3		100 g citric acid ($C_6H_6O_7$) 50 mL sulfuric acid (H_2SO_4, sp gr 1.84) 2 g inhibitor (diorthotolyl thiourea or quinoline ethyliodide or betanaphthol quinoline) Reagent water to make 1000 mL	5 min	60°C	...

Designation	Material	Solution	Time	Temperature	Remarks
C.7.4		200 g sodium hydroxide (NaOH) 30 g potassium permanganate ($KMnO_4$) Reagent water to make 1000 mL *followed by* 100 g diammonium citrate ($(NH_4)_2HC_6H_5O_7$) Reagent water to make 1000 mL	5 min	Boiling	...
C.7.5		100 mL nitric acid (HNO_3, sp gr 1.42) 20 mL hydrofluoric acid (HF, sp gr 1.198–48 %) Reagent water to make 1000 mL	5 to 20 min	20 to 25°C	...
C.7.6		200 g sodium hydroxide (NaOH) 50 g zinc powder. Reagent water to make 1000 mL	20 min	Boiling	Caution should be exercised in the use of any zinc dust since spontaneous ignition upon exposure to air can occur.
C.8.1	Tin and Tin Alloys	150 g trisodium phosphate ($Na_3PO_4 \cdot 12H_2O$) Reagent water to make 1000 mL	10 min	Boiling	...
C.8.2		50 mL hydrochloric acid (HCl, sp gr 1.19) Reagent water to make 1000 mL	10 min	20°C	...
C.9.1	Zinc and Zinc Alloys	150 mL ammonium hydroxide (NH_4OH, sp gr 0.90) Reagent water to make 1000 mL *followed by* 50 g chromium trioxide (CrO_3) 10 g silver nitrate ($AgNO_3$) Reagent water to make 1000 mL	15 to 20 s	Boiling	The silver nitrate should be dissolved in water and added to the boiling chromic acid to prevent excessive crystallization of silver chromate. The chromic acid must be sulfate free to avoid attack of the zinc base metal.
C.9.2		100 g ammonium chloride (NH_4Cl) Reagent water to make 1000 mL	2 to 5 min	70°C	...
C.9.3		200 g chromium trioxide (CrO_3) Reagent water to make 1000 mL	1 min	80°C	Chloride contamination of the chromic acid from corrosion products formed in salt environments should be avoided to prevent attack of the zinc base metal.
C.9.4		85 mL hydriodic acid (HI, sp gr 1.5) Reagent water to make 1000 mL	15s	20 to 25°C	Some zinc base metal may be removed. A control specimen (3.1.1) should be employed.
C.9.5		100 g ammonium persulfate ($(NH_4)_2S_2O_8$) Reagent water to make 1000 mL	5 min	20 to 25°C	Particularly recommended for galvanized steel.
C.9.6		100 g ammonium acetate (CH_3COONH_4) Reagent water to make 1000 mL	2 to 5 min	70°C	...

Electrolytic Cleaning Procedures for Removal of Corrosion Products[2]

Designation	Material	Solution	Time	Temperature	Remarks
E.1.1	Iron, Cast Iron, Steel	75 g sodium hydroxide (NaOH) 25 g sodium sulfate (Na_2SO_4) 75 g sodium carbonate (Na_2CO_3) Reagent water to make 1000 mL	20 to 40 min	20 to 25°C	Cathodic treatment with 100 to 200 A/m^2 current density. Use carbon, platinum or stainless steel anode.
E.1.2		28 mL sulfuric acid (H_2SO_4, sp gr 1.84) 0.5 g inhibitor (diorthotolyl thiourea or quinoline ethyliodide or betanaphthol quinoline). Reagent water to make 1000 mL	3 min	75°C	Cathodic treatment with 2000 A/m^2 current density. Use carbon, platinum or lead anode.
E.1.3		100 g diammonium citrate ($(NH_4)_2HC_6H_5O_7$) Reagent water to make 1000 mL	5 min	20 to 25°C	Cathodic treatment with 100 A/m^2 current density. Use carbon or platinum anode.
E.2.1	Lead and Lead Alloys	28 mL sulfuric acid (H_2SO_4, sp gr 1.84) 0.5 g inhibitor (diorthotolyl thiourea or quinoline ethyliodide or betanaphthol quinoline) Reagent water to make 1000 mL	3 min	75° C	Cathodic treatment with 2000 A/m^2 current density. Use carbon, platinum or lead anode.
E.3.1	Copper and Copper Alloys	7.5 g potassium chloride (KCl) Reagent water to make 1000 mL	1 to 3	20 to 25°C	Cathodic treatment with 100 A/m^2 current density. Use carbon or platinum anode.
E.4.1	Zinc and Cadmium	50 g dibasic sodium phosphate (Na_2HPO_4) Reagent water to make 1000 mL	5 min	70°C	Cathodic treatment with 110 A/m^2 current density. Specimen must be energized prior to immersion. Use carbon, platinum or stainless steel anode.
E.4.2		100 g sodium hydroxide (NaOH) Reagent water to make 1000 mL	1 to 2 min	20 to 25°C	Cathodic treatment with 100 A/m^2 current density. Specimen must be energized prior to immersion. Use carbon, platinum or stainless steel anode.
E.5.1	General (excluding Aluminum, Magnesium and Tin Alloys)	20 g sodium hydroxide (NaOH) Reagent water to make 1000 mL	5 to 10 min	20 to 25°C	Cathodic treatment with 300 A/m^2 current density. A S31600 stainless steel anode may be used.

[2]See ASTM G1, Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens.