KEY: T refers to tables. F refers to figures.

A
Abbreviations, 476–478
Activity, coefficient:
definition, 24
rules, 451–452	tables, 453–455
Aircraft:
aluminum alloys in, 395
Boeing 777, 395
fretting corrosion, 182
hot corrosion, 229–230
microbiologically influenced corrosion,
388–389
stress-corrosion cracking, 395
titanium, 425
Aluminum, 383–398
anodic protection,
anodizing, 287–288, 296
atmospheric corrosion, 1947, 383, 391
cathodic protection of, 252, 260, 261, 384, 395
chlorinated solvents, corrosion in, 389–391
inhibitors for, 390–391
mechanism of, 390–391
water, effect of, 390F
coatings, 280–281
corrosion characteristics, 384–392
by microbiological constituents in fuel,
388–389
galvanic coupling of, 392–393
nitric acid, corrosion rates in, 392
oxide coatings on, 287–288, 383, 386
painting of, 296
passivity of, 83, 383, 384, 386, 388
soil corrosion, 208
steam, corrosion in, 384
vapor degreasing of, 293
waters, corrosion in, 384–386
pH, effect of, 387
pitting, 98, 99
Aluminum alloys, 393–395
anodes in impressed current cathodic
protection, 259
clad, 384, 395
compositions, 385F
exfoliation of, 394
intergranular corrosion, Al–Cu alloys,
393–394
sacrificial anodes, 254–255
stress-corrosion cracking, 384, 394–395
Amorphous alloys, 335
Amphoteric metals, 12, 47, 79, 245, 260, 279, 446
Anion, definition, 13
Anode:
definition, 11–13
materials, for cathodic protection, 258–260
sacrificial, 144, 251, 252, 254–257, 263, 354, 370, 378
Anode–cathode area ratio, 56, 67–69, 71–75, 123, 132, 208–210
magnesium, galvanic corrosion of, 402
tantalum, 442
Anodic protection, 263–264
by alloying, 90–92
of aluminum, 264, 386
theory of, 90–92
Anodizing:
aluminum, 287–288, 296
magnesium, 403
Atmospheric corrosion, 191–204
avoiding, 201–202
comparison with seawater and soils, 1957

corrosion product films, protection by, 192–195
corrosion rates, steels, 193F
  alloying, effect of, 202T
  various metals, 194T
critical humidity, 199–200
  factors influencing, 195–200
gases in atmosphere, effect of, 197–199
  sulfur dioxide content of air, 197–198
  moisture, effect of, 199–200
  particulate matter, effect of, 196–197
  time of wetness, 199

types of atmospheres, 192

Automobiles, 4, 196, 295
  aluminum alloys in, 394–395
  body panels:
    electrogalvanization, 270
    painting, 295
    phosphate coating, 287
  engines, 3
  Ford, 404
  fretting corrosion, 182
  Honda, 395
  lead in, 447
  magnesium in, 399, 404
  nickel coatings, 272
  mufflers, 2, 280
  painting, 295
  stainless steels in, 341
  Volkswagen, 399

B

Backfill, for cathodic protection, 255, 259

Bacteria, 4, 118–120, 206–207, 279, 298, 309,
  367, 388–389

Blister, 66

Blister cracking, 170–172

Boiler corrosion, 323–330
  alkali addition, effect of, 327–328
  embrittlement detector, 324–325
  inhibitors for, 328
  mechanisms of, 328–330
  oxygen, dissolved, effect of, 329
  oxygen scavengers, 318–319, 330

Boiler water, treatment of, 326–328
  alkali addition, 327–328
  carbon dioxide removal, 326–327
  inhibitor addition, 328
  oxygen removal, 326
  phosphate addition, 328

Brasses, 371–378
  naval, red, yellow, 371–372
  see also Copper–zinc alloys

Bridges, 2
  cathodic protection for, 253
  steel reinforcements in, 144
  failure by stress-corrosion cracking, 153,
    169–170
  painting, 290
  weathering steels for, 201

Bronzes, 13, 252, 270, 371–372

C

Cadmium, 70–71, 168, 178, 184, 198, 231, 264,
  271, 274, 276–277, 288, 314, 392–393,
  toxic properties of, 277, 392–393

Catalytic properties and passivity, 108–109
  hydrogen overpotential, relation to, 65

Cathode, definition, 11–13

Cathodic protection, 251–267
  anode materials for, 258–260
  backfill, use of, 255, 259
  coatings, combined use with, 255–257
  criteria of protection, 260–263
  doubtful, 262
  potential measurements, 260–262
  current, magnitude required, 77–79,
    257–258
  economics of, 263
  history of, 252–253
  how applied, 253–254
  overprotection, effect of, 259–260
  pitting, used to avoid, 261–262, 354
  potential decay along pipeline, 257
  derivation of formula for, 467–469
  steel reinforcements in concrete, 144, 253
  stress-corrosion cracking, to avoid:
    in aluminum alloys, 384, 395
    in brasses, 378
    in stainless steels, 360
    in steel, 155–156, 162
    in titanium alloys,
      theory of, 77–79
  Cation, definition, 13

Caustic embrittlement, 152

Cavitation-erosion, 130–131
  in diesel engine liner, 131F

Cells:
  Daniell, 54–55
  galvanic, 11–12, 22, 26, 54, 68, 84, 115, 143,
    157, 197, 207, 254, 280, 343, 369
  local-action, 10–11, 68, 142, 261
  passive–active, 96, 280, 352
  reference, 34–37
  calomel, 35–36
  copper–copper sulfate, 36–37
  silver–silver chloride, 36–37
types, in corrosion reactions, 13–15
corrosion reactions, 13–15
concentration, 13–14
differential temperature, 14–15
dissimilar electrode, 13
Cement, Portland, as cause of corrosion:
of aluminum, 388, 391
of lead, 446
as protective coating for steel, 286
steel reinforcements, failure of, 143–145
galvanic effects of, 144
Chromates, see Passivators
Chromium–iron alloys:
critical composition for passivity, 100–101
critical current densities for passivity, 101F
oxidation, elevated temperatures, 232–235
effect of yttrium, 234–235
maximum temperatures in air, 235T
potentials of, in 4% NaCl, 101F
Flade, 88F
see also Stainless steels
Chromium–nickel alloys:
critical composition for passivity, 102
intergranular corrosion, 415
oxidation, elevated temperatures, 226T, 236–237
Clean Air Act, 191, 198, 289, 295
Coatings:
compliant, 289
inorganic, 285–288
chemical conversion, 286–288
chromate, 288
oxide, 287–288
phosphate, 286–287
as preparation for painting, 295–296
Portland cement, 286
vitreous enamel, 285–286
metallic, 269–283
aluminum, 280–281
application, methods of, 269–271
cadmium, 276–277
chromium, 279–280
classification, 271–272
lead, 274
nickel, 272–274
electroless, 273–274
fogging of, 273
thickness of, 272–273
tin, 277–279
zinc, 274–276
atmospheric corrosion, 198
seawater corrosion, 275
soil corrosion, 208
polarity reversal in hot waters, 276
see also Steel, galvanized
organic, 289–301
cathodic protection, combined use with, 255–257
filiform corrosion, 296–299
pigments, inhibiting, 291–292
plastic, 299–300
prime coat, 291–292, 294, 295, 296, 299
requirements for, 291–292
rules for applying, 295
surface preparation, 293–295
effect on life, 295T
Cobalt and cobalt alloys, 419–423
cavitation-erosion, 420, 423
compositions, 422T
corrosion characteristics, 419–423
fretting corrosion, 420, 423
Cold working, effect on corrosion:
iron and steel, 149–150
nickel, 150
pure iron, 150F
Complexes, chemical, effect on Emf, 30–32
Concrete, 143–145, 253, 388, 391
Condenser tube alloys, 378–379
Converson factors:
corrosion rates, 474–475T
to current densities, 475T
Copper, 367–381
atmospheric corrosion, 194T, 195T, 197–199
blue staining, caused by, 321, 369
corrosion characteristics, 367–371
deposit attack, 370
hydrogen, reaction with, 231–232
impingement attack, 17, 368–372, 379, 411
inhibitor for tarnish of, 314
oxidation, high temperature, 230–232
pitting of, 369–370, 371, 378
seawater corrosion, 195T
soil corrosion, 195T, 208, 209T
stress-corrosion cracking, 371, 374
waters, corrosion by, 369–371
Copper–nickel alloys, for condenser tubes, 378–379
see also Nickel alloys, copper–nickel
Copper–zinc alloys, 371–378
dezincification, 17, 252, 334, 371–374
effect of Zn content, 372F
mechanism of, 334, 374
impingement attack, effect of Zn content, 372F
stress-corrosion cracking, 374–378
  effect of applied potential, 377
  effect of Zn content, 372
  mercurous nitrate test, 376
  prevention, 378
Corrosion:
  alloying, effect of, 333–335
  cost, 2–5
  current and corrosion rate, 56, 475
  importance of, 2–5
  direct and indirect losses, 2–5
  products, protective, in atmospheric
  corrosion, 192–195
  rates, calculation of, from polarization data,
  71–73, 456–461
  classification for handling chemical media,
  16
  control of, anodic, cathodic, 68–69
  derivation of formula for, 456–461
  polarization, influence on, 68–71
  scientist and engineer, 1–2
  tendency and free energy, 21–22
  types, 15–18
Corrosion-erosion, definition of, 17
Corrosion fatigue, 173–180
  appearance of, 174 (Photo)
  definition, 18, 173–174
  effect of oxygen, moisture, 175
  mechanism of, 179–180
  minimum corrosion rate for, 178
  prevention, 178–179
  strength, values of, 177
Crazing, 286
Crevice corrosion, 14, 29, 99, 117, 173, 342,
  350–351, 352–354, 361, 412, 416–417,
  429–430, 432
Critical pitting potential, 97–99, 160, 264, 351–354,
  384–386, 421, 429, 437
Critical pitting temperature, 99–100, 351–352
Crystal face, effect on corrosion, 13, 149
  effect on oxidation, 230–231, 232
Current density:
  critical for passivity, 85–86, 90, 117, 242, 411
  for Cr–Fe alloys, 101
  for Ni–Cu alloys, 104
  exchange, 61
  limiting, 58–60
  passive, 85
  for Ni–Cu alloys, 104

D
Deactivation of water:
  definition, 317
  by hydrazine, 318–319
  by ion-exchange resins, 326
  by sodium sulfite, 318, 326
Dealloying, 118, 172, 372–374
Depolarization:
  in acids, 124–125
  by oxygen, 72, 116, 122, 124, 131–133, 139,
  262, 458
Deposit attack, 370
Dezincification:
  Cu–Zn alloys, 334, 371–374
  definition, 17
  mechanism, 374
Diesel engines, 130, 215, 322,

E
Electrochemical equivalent, 10
Electrochemical impedance spectroscopy,
  75–77
Electrochemical mechanism:
  of corrosion, 9–18, 22, 70–71, 143
  for corrosion of iron and steel, 115–116
  of passivation, 89
  of pitting, 96, 351–353
  of stress-corrosion cracking, 157–158, 190,
  377
Electrode:
  copper–copper sulfate, 36–37
  hydrogen, 24–25
  oxygen, 28–30
  reference, 34–38
  standard or normal hydrogen, 24–25
Electron configuration theory, 102–108
Emf:
  calculation of, 25–28
  relation to Gibbs free energy, 22
  Series, definition of, 30
    Table, 31T
Endurance limit, 18, 141
Environmental Protection Agency (EPA), 191,
  196, 369, 447
Exfoliation, 394

F
Faraday, value of, 22
Faraday’s law, 9–11, 56, 85, 178, 244, 259,
Fatigue, affected by air, moisture, 175
  limit, definition of, 18, 173
  strength, definition of, 173
  see also Corrosion fatigue
Filiform corrosion, 279, 296–299
photos, 297
theory of, 298–299
Films, oxide:
- isolation of, 94
- passive, oxidizing properties, 93–94
- thickness of:
  - on aluminum, 383
  - on iron, 93–94
Flade potential:
- aluminum, 383
- definition, 86
- chromium, 279
- chromium–iron alloys, 88F
- iron, 47, 84–89, 93–94, 112
- nickel, 410
- nickel–copper alloys, 106
- nickel–molybdenum alloys, 412
- tantalum, 441
- titanium, 426
Fogging, 16, 273, 411
Fouling, marine:
- Cu²⁺ concentration to prevent, 103–105, 252, 369
- of Cu–Ni alloys, 103–105, 104F
- of stainless steel, 351
Fracture mechanics, 162–166
Fretting corrosion, 180–184
- aircraft, 182
- automobiles, 182
- cobalt alloys, 420, 423
- definition, 17, 180–181
- equation for weight loss, 183
- derivation of, 471–474
- factors causing, of steel
- mechanism, 182–184
- nuclear reactors, 182
- prevention, 184
- railroad car wheels, 182
Fugacity, 24
Furnace windings, 236, 237

G
Galvanic coupling:
- of aluminum, 391–393
- in aerated media, 127
- in deaerated media, 127–129
- of different steels, 141–142
- in soils, 206
- effects of, at elevated temperatures, 227–228
- hydrogen cracking of stainless steels, caused by, 357
- hydrogen embrittlement of Ta, caused by, iron–gold, 306
- in natural waters and soils, 141–142
- and passivity of stainless steels, 361
Galvanic Series:
- definition, 32
- in seawater, 33F
Galvanized steel, see Steel, galvanized
Glass, cavitation–erosion, 130
coatings, 256, 285–286
electroless nickel coatings on, 274
stress-sorption cracking, 160
Glass electrode, 25
Glassy alloys, 335
Gmd, conversion factors of mm/y, 474–475
- definition, 16
- coatings, electrical contacts, 182
coupled to iron, 306
fatigue, 175
Graphitic corrosion, 138, 142, 206
Gun barrels, protecting, 287

H
Humidity:
critical in atmospheric corrosion, 196, 199–201
and filiform corrosion, 298
and growth of bacteria, 120
and stress-corrosion cracking, 165, 376
Hydrogen:
cracking, 65–66, 166–172
- and cadmium coatings, 276
- and cathodic protection, 252, 259, 267
- of cobalt alloys, 421–423
- mechanism, 167–170
- metal flaws, effect of, 170–172
- of stainless steels, 354–361
- of steel, 166–172
- of steel reinforcements in concrete, 145
disease, in copper, 231–232
- in silver, 203
electrode, 24–25, 25F
- standard, 25
embrittlement, 54, 158, 166–169
- of aluminum alloys, 395
- and cathodic protection, 259
- of magnesium alloys, 402
caused by microbiologically influenced corrosion, 118
caused by pickling inhibitors, 312
- of Ta,
- of ultra-high-strength steels, 357
overpotential, 60–61, 62T, 63–66, 70, 80–81, 90, 116, 123, 125–129, 139, 143, 149–150, 267, 278–279, 310, 402, 412, 448

standard scale, definition of, 25

I

Impingement attack:
of condenser alloys, 379
of copper, 368–370
of copper–tin alloys, 371
of copper–zinc alloys, 371–372
definition, 16–17
photo, 368

Inhibition efficiency, definition, 311

Inhibitors, 2, 3, 303–316
for aluminum, 384, 390, 392
classification, 303
for corrosion fatigue, 178–179
and critical pitting potential, 97
definition, 303
for diesel-engine cylinder liners, 130
for engine cooling systems, 323
evaluation of, 73
in foods, 278
for industrial waters, 318
boiler waters, 152, 328
cooling waters, 322–323
for iron and steel, 130, 133, 143
for lead, 447
mechanism of, 304–308
nontoxic, 323
oxygen, as inhibitor in acids, 125
in phosphate coatings, 287
pickling, 310–313
applications of, 294, 312–313
concentration, effect of, 312F
hydrogen embrittlement, caused by, 312
pigments for paints, 291–292
slushing compounds, 313
sodium:
benzoate, 306, 384
borate, 133, 306, 322
polyphosphate, 306–307, 323
silicate, 133
for soil corrosion, 206
for stainless steels, 157, 361
pitting corrosion, 350–351
for stress-corrosion cracking, of brass, 376, 378
of steel, 152–156, 157
of stainless steels, 157
of titanium alloys, 157, 430–431
for tarnishing of copper, 314
toxicity, 303–304, 309

in vapor degreasing aluminum, 293
calculation of, 474–475
definition, 16
IR drop, 56–57, 63, 68, 73, 74, 88, 262–263, 456

Ion implantation, 270

Ionization constant of water, various temperatures, 287

Iron, 115–148
acids:
citric, rates in, 71T, 139T
dissolved oxygen:
effect of, 124–125
inhibition by, 125–127
HCl + NaCl, rates in, 139T
velocity, effect of, 125–127
anaerobic bacteria, effect of, 118–120
anodic protection, 90, 263–264
atmospheric corrosion, 191–204
cast,
coupled to steel, 142
graphitic corrosion, 138, 142, 206
soil corrosion, 138, 206
water pipe, 286
in water, 138
composition, effects of, 138–142
heat treatment, effect of, 142–143
hydrogen cracking, 166–172
delay time and H₂ content, 168F
metallurgical factors, effect of, 138–143
oxidation, elevated temperatures:
in oxygen, 232–234
in steam, 323–326
effect of pH, 327F
oxygen, dissolved, effect of, 116–118
pH, effect of, 120–123
salts, dissolved, effect of, 131–138
seawater, rates in, 124T, 195T
soil corrosion, 205–213
stress, effect of cold work, 149–150
stress-corrosion cracking, 151–156
effect of:
  - alkalis, 151–152
  - carbon monoxide–carbon dioxide, 153
cold work, 153–155
  - illuminating gas (HCN), 153
  - liquid ammonia, 153
  - nitrates, 151–155
  - silicates, 152
temperature, effect of in aqueous media,
  - 120
velocity, effect of:
  - in acids, 125–127
  - in natural waters, 129–130
wrought, 123, 124T, 138, 206, 209T
see also Steel

K
Knife-line attack, 348

L
Lead, 445–449
  - and air quality, 191
  - atmospheric corrosion, 192, 194T, 198
cathodic protection of, 251, 260, 261, 262T,
chemical conversion coatings on, 286
corrosion characteristics:
  - Pb-acid battery grids, 447–448
  - in differential temperature cells, 15
fatigue cracks in, 174
hydrogen overpotential of, 62T, 65
oxidation, 231
  - in paints, 290, 291–292, 295T, 296
  - passivation of, 84, 92, 127
  - polarization of, 68
soil corrosion, 207, 208, 209T,
stray current corrosion, 242, 244T, 245
toxic properties of, 4, 393
  - in water, 137, 317, 321,
  - woods, corroded by, 446
Lead and Copper Rule, EPA, 369, 447
Liquid-metal embrittlement, 158, 160, 165
Local-action cells, 10–11, 68, 142, 261
current, 10, 259, 266
Luggin capillary, 56, 57F

M
Magnesium, 399–406
  - alloy compositions, 403T
  - coatings on, 403–404
corrosion characteristics:
  - alloys, 400–403, 404–404
  - pure magnesium, 399–400
as sacrificial anode, 254–255
efficiency of, 255
  - for hot water tanks, 256F
stress-corrosion cracking, 402–403
tolerance limit, definition of, 400
  - for iron, 401F
univalent ion, 259
mdd, conversion factors to ipy, 474–475
definition of, 16

N
Nernst equation, derivation of, 22–24
Nickel, 408–411
  - atmospheric corrosion, 194T, 198–201
corrosion characteristics, 408–411
Flade potential, 410
oxidation, elevated temperatures, 216–217,
  - 236–237, 410
  - alloyed with Cr, 226T, 234F, 236–237
  - intergranular, 236–237, 410
Nickel alloys, 411–417
  - compositions, 413T
  - critical pitting potential, 98T
irradiation-assisted stress-corrosion cracking, 172
nickel–chromium, 236–237, 411–412
nickel–chromium–iron, 236, 414–415
  - in pressurized water reactors, 414–415
nickel–copper, 414
  - atmospheric corrosion, 194T
cupro-nickel, 103, 378–379, 411
  - corrosion fatigue, 177T
  - in condenser tubes, 378–379
corrosion in 3% NaCl, 103F
fouling of, in seawater, 105
passive current densities, 104F
  - pitting, in seawater, 104F
stress-corrosion cracking, 379
nickel–molybdenum, 412, 415–416
behavior in acids,
  - Nitrites, see Passivators
Nuclear reactors, 172–173, 182, 348, 437

O
Overpotential:
definition, 60
hydrogen, 60–61, 63–66
  factors affecting, 63–66
  mechanism of, 64–65
  values of, 62T
metal deposition and dissolution, 61
  values of, 62T
oxygen, 61
  values of, 44T
Overvoltage,
definition, 60
Oxidation, 215–240
  catastrophic, hot ash, 229
  of copper, 230–232
  equations expressing rate, 220–223
  galvanic effects, 227–228
  initial, thin film, 216–218
  internal, 231
  iron and iron alloys, 232–233
  iron–chromium alloys, 235–236
  life test, ASTM, 233–234
  nickel and nickel alloys, 236–237
  coupled to Pt in borax, 227–228
  reactive element effect, 215, 234–237
  Wagner theory, 223–224
  Zn alloyed with Al, Li, 227T
Oxidation-resistant alloys, 234–237
  Reactive element effect, 234–235
Oxides, properties, 224–227
  p-, n-type, 224–225

P
Paints, 289–291
  applying, 295–296
see also Coatings, organic
Parting, definition, 17, 334
Passivators, 303–310
  applications, 308–310
  chromates, 303–310
  for cooling waters, 322–323
  toxicity, 304, 322–323
  critical concentrations of chlorides and sulfates, 310T
  effect on steel, various temperatures and Cl– concentrations, 308T
  nontoxic alternatives, 323
  critical concentration, 305
  definition, 303
  examples of, 88
  oxygen as, 125, 306
  sodium, benzoate, 306, 384
  borate, 133, 306, 322
  nitrite, 303–306, 309–310
  corrosion of steel, effect of concentration, 309T
  critical concentrations of chlorides and sulfates, 310T
  polyphosphate, 306–307, 323
  combined with chromates, 309
  for treatment of municipal waters, 321
  disposal, 322
  silicate, 133, 152, 306
  for treatment of potable waters, 321–322
  theory of, 88–90, 304–308
  toxicity, 303–304
see also Inhibitors
Passivity, 83–113
  of alloys, 100–108
    critical compositions, 100–102
    breakdown of, 89, 90, 94, 96
    catalytic properties, relation to, 108–109
    cathodic polarization, effect of, 108
    chlorides, action of, 96–100
    definitions, 84
    film thickness:
      on aluminum, 383
      on iron, 93–96
    of iron:
      in nitric acid, 89–90
      in sulfuric acid, 84–87
    theories of, 92–96
    adsorption, 92–94, 96, 99, 102, 108
    electron configuration, 102, 108–109
    oxide-film, 92, 96, 102
Patina, on copper, 198–199
pH:
  aluminum, effect of, 387–388
  definition, 28
  iron, effect of, 120–123
  measurement, 28
  values for water at various temperatures, 28T
  zinc, effect of, 274–275
Pilling and Bedworth rule, 6, 219–220
Pipelines, 2, 4
  cathodic protection of, 211, 253–255, 257–263, 467–470
  microbiologically influenced corrosion of, 120
  hydrogen-induced cracking of, 140, 170
  inhibitors, 309
  pitting of, 210
  soil corrosion of, 205, 206
  stray-current corrosion of, 241–244, 247
  stress-corrosion cracking of, 153, 210–211, 300
Pitting:
  in aluminum, 384–386
  in condenser alloys, 378–379
in copper, 369–370
critical potential for, 97–99
critical temperature for, 99–100
definition, 16
elongated, 352, 353F
factor, 16
in stainless steels, 350–354
tetrafluorethylene, 184, 300
Plastics, coatings, used for, 299–300
Polarization:
causes of, 58–63
activation, 60–61
concentration, 58–60
IR drop, 61–63
corrosion rates:
anode–cathode areas:
effect of, 73–75
calculation of, 71–73
relation to, 68–71
definition, 54
galvanostatic, for iron, 86F
how measured, 56–58
potentiostatic, for iron, 85F
Potential:
calculation of, 22–28
corrosion, 54
definition, 56
measurement, 66
critical:
for pitting, 97–99
for stress-corrosion cracking, 158–162,
355–358
decay along pipeline:
derivation of formula, 467–469
formula, 257
definition, 24–26
drop along soil surface by current entering
pipe, 245, 469–470
Flade, chromium, value for, 279
chromium–iron alloys, 88F
definition, 86
iron, value for, 86
as calculated, 93, 112
in chromates, 88–89
nickel, value for, 410
passivity, relation to stability of, 87
pH, dependence on, 86–87
hydrogen, normal, 25
standard, 25
liquid-junction, 33–34
characteristic values, 34T
sign of, 25–28
standard, 31T, 476T
definition, 24
standard hydrogen, definition, 25
Potentiometer, 22, 26, 66
Potentiostat, 66–67, 85, 263
Potentiostatic polarization, 85, 97, 105, 242
Pourbaix diagrams, 43–51
aluminum, 47–48, 383
basis of, 43–44
copper, 367–368
iron, 45–47
lead, 445–446
limitations, 49
magnesium, 48–49, 400
nickel, 408–410
tantalum, 441–442
titanium, 419–420
water, 44–45
zirconium, 435–436
R
Radiation damage, 172–173
Reaction limit, 334
values, gold alloys, 334F
Reactive element effect, 215, 234–237
Resistivity:
IR drop in electrolytes, 58, 61–63
in soil, 206–207
measurement, 246
formula for, derivation of, 470–471
Ring-worm corrosion, 143
Risk, 5, 7–8
Rust:
composition, 116
definition, 1
iron, effect on corrosion of, 14, 15F,
protection by, in atmospheric corrosion,
192–195, 201
S
Saturation index:
alteration of, by water treatment, 136, 321
calculation of, 134–136, 417F
derivation of equation for, 461–463
effect of temperature, 136
limitations of, 137–138
and municipal waters, treatment of, 321–322
Schikorr reaction, 325
Season cracking, 334–335
Seawater:
aluminum in, 280, 386, 392
galvanic coupling, 393
cathodic protection in, 254–256, 2587, 261,
272,
coal-tar coatings, 291
copper–aluminum alloys in, 371
aluminum alloys in, 393–394
stainless steels, 156, 172, 343–347, 350, 351, 359–361
slushing compounds, 313
soils, corrosion in, 205–213
avoiding, 211
in cinders, 208
depth of burial, effect on, 207
factors affecting, 206–207
pitting, 208–210
rates, 1957, 209T
resistivity measurements, 207, 246
stress-corrosion cracking, 210–211
stainless steels, 335–365
anodic protection of, 90–91, 263–264
cold work, 343
compositions, 338–340T
corrosion resistance, general, 361–362
cold work, 343
compositions, 338–340T
corrosion resistance, general, 361–362
crevice corrosion, 350–351
avoiding, 354
definition, 100, 335
galvanic coupling, 357, 361
heat treatment, for optimum corrosion resistance, 342–343
sensitizing, 343
austenitic, 343–345, 344F
ferritic, 349
desensitizing, 343
stainless steels, 335–365
anodic protection of, 90–91, 263–264
cold work, 343
compositions, 338–340T
corrosion resistance, general, 361–362
crevice corrosion, 350–351
avoiding, 354
definition, 100, 335
galvanic coupling, 357, 361
heat treatment, for optimum corrosion resistance, 342–343
sensitizing, 343
austenitic, 343–345, 344F
ferritic, 349
desensitizing, 343
stainless steels, 335–365
anodic protection of, 90–91, 263–264
cold work, 343
compositions, 338–340T
corrosion resistance, general, 361–362
crevice corrosion, 350–351
avoiding, 354
definition, 100, 335
galvanic coupling, 357, 361
heat treatment, for optimum corrosion resistance, 342–343
sensitizing, 343
austenitic, 343–345, 344F
ferritic, 349
desensitizing, 343
stainless steels, 335–365
anodic protection of, 90–91, 263–264
cold work, 343
compositions, 338–340T
corrosion resistance, general, 361–362
crevice corrosion, 350–351
avoiding, 354
definition, 100, 335
galvanic coupling, 357, 361
heat treatment, for optimum corrosion resistance, 342–343
sensitizing, 343
austenitic, 343–345, 344F
ferritic, 349

defense against, 211
in cinders, 208

slushing compounds, 313
soils, corrosion in, 205–213
avoiding, 211
in cinders, 208
defense against, 211
in cinders, 208
ferritic and martensitic, 354, 356–357, 361
weld decay, 344, 345
Steam:
condenser corrosion, 327
of aluminum in, 386
of iron in, 323–326
of zirconium in, 437–438
return-line corrosion, 327, 328
Steel:
atmospheric corrosion, 193F, 194T, 195T, 202T
Bessemer, oxygen-furnace, 138
carbon content, effect on corrosion, in 3% NaCl, 124T
in hydrochloric acid, 151
in seawater, 139
cold rolling, effect of, 149–150
composition, effects of, 138–141
corrosion fatigue, 173–180
fretting corrosion, 180–184
galvanic coupling, effects of, 141–142
galvanized, 274–276
corrosion of:
atmospheric, 198, 274, 275T
in soils, 206, 208, 209T
first patent, 252
painting of, 296
pitting of, in hot water, 276
heat treatment, effect on corrosion, in water, 124T
in acids, 143
low alloy, 138–142, 206
atmospheric corrosion, 193F, 194T, 201
copper-bearing, 124T, 140–141, 206
atmospheric corrosion, 193F, 202T
corrosion in aqueous media, 123, 138–142
corrosion fatigue, 177T
oxide coatings on, formation of, 287
pickling of, 294
reinforcements in concrete, 143–145
cathodic protection, 144, 253
soils, corrosion in, 206, 207, 208, 209T, 210
stress-corrosion cracking in, 210–211
stainless, see Stainless steels
weathering, 201
see also Iron
Stepwise cracking, 140, 166
Stern–Geary equation, 72–73
derivation of, 456–458
general corrosion, 458–461
Stray-current corrosion, 241–249
avoiding, 246–247
damage by, ac vs. dc, 241–242
to amphoteric metals, 245
quantitative values, 244
detection of, 245
pipe, inside of, 243–244
sources of, 242–244
Stress, residual, 149
in brass, 376
and corrosion fatigue, 177
and hydrogen-induced cracking, 170
in magnesium alloys, 402–403
in stainless steels, 357
and stress-corrosion cracking of steel, 151, 155, 156T
in zirconium alloys, 437
Stress-corrosion:
of aluminum alloys, 394–395
of bridge cable, 153
of copper–zinc alloys, 162, 163F, 374–379
critical crack depth, 165–166
definition, 18
initiation of, critical potentials for, 161–162
of iron and steel, 151–156
of magnesium alloys, 402–404
mechanisms, 156–166
of pipelines, 210–211
rate of crack growth, 162–166
of stainless steels, 354–361
surface flaws, effect of, 166, 431
of titanium alloys, 431
Stress intensity factor, 164–166, 171–172
Stress-sorption cracking, 158–161, 395
Subscale formation, 231
Sulfidation, 18, 226, 230, 237, 409T
Sulfide stress cracking, 166–167, 421
effect of surface flaws, 171–172
T
Tafel equation, 61, 64, 71, 457, 459
Tantalum, 441–443
as alloying element, 155
corrosion characteristics, 436, 441–443
galvanic effect, 227, 228F
and glass coatings, 286
hydrogen embrittlement, avoiding, 441–442
passivity, 96, 441–442
Telluric currents, 241
Terne plate, 274
Thermal spraying, 270
Tin:
atmospheric corrosion, 194T
coatings, 277–279
complexes, effect on corrosion, 30–32

corrosion characteristics, 279

Titanium, 425–434
  alloy compositions, 428
  corrosion characteristics, 425–432, 436
    in alkali–hydrogen peroxide solution, 427
  Flade potential, 426
  hydrochloric acid, corrosion rates in
    inhibited, 427–429, 428
    effect of alloyed Pt or Pd, 428
  nitric acid, fuming, reaction with, 427
  pitting and crevice corrosion, 429–430
    in bromides, iodides, 429–430
    pitting potentials in chlorides at elevated
      temperatures, 430
  seawater, resistance to, 429–430
  stress-corrosion cracking of alloys, 431
  cathodic protection against, 431
  inhibiting ions for, 431

Transition metals:
  catalytic properties, 108–109
  overpotential for deposition or dissolution, 61
  passive properties, 93
  Transpassivity, definition, 92
  Tungsten, 96, 220, 221, 412, 421.

V
  Valves, corrosion of, 142
  Vanadium, as cause of catastrophic oxidation, 229

W
  Wagner:
    definition of passivity, 84
    theory of oxidation, 223–224
    and Traud experiment, 70
  Wash primer, 296

Water, treatment of, 317–332
  boiler, 323–328
  cooling, 322–323
  hot-water heating systems, 321–322
  municipal supplies, 321–322

Welds:
  knife-line attack, 348
  weld decay, 345 (Photo)
    definition, 344

Y

Z
  Zinc:
    atmospheric corrosion, 194, 195T, 198, 199
    chromate coatings on, 288
    coatings on steel, 208, 274–276. see also
      Steel, galvanized
    electrogalvanizing, 270
    oxidation of, in O₂, 227T
    painting of, 296
    pH, effect of, 275F
    -rich paints, 292, 296
    seawater corrosion, 195T, 275
    soil corrosion, 195T, 207, 208, 209T, 211
  Zirconium, 435–440
    corrosion characteristics, 435–439
    pitting in chlorides, critical potentials for, 437
    Pourbaix diagram, 436
    radiation, effect on, 173
    steam, behavior in, 437–438, 439F
      effect of alloyed tin, 438
    stress-corrosion cracking, 437
    transition point, 436, 438, 439F
    water, high temperature, corrosion by,
      437–439