

# Subject Index

## A

- Alkaline environments, 45
- Aluminum flashing installation, 201, 202, 203
- Aluminum foil, 51, 57
  - applications and performance of, 196-198
  - fire risk, 194-196
  - in stress corrosion cracking prevention, 188
- Aluminum sulfate, 139
- American Petroleum Institute Pressure Vessel Inspection Code 510, 26
- Ammonium sulfate, 139, 140
- Apparatus and test procedure for ASTM C 692, 211
  - modified apparatus, illustration, 215
- Aqueous environment (*see* Water)
- Argon sensitization, 217
  - table, 218
- Asbestos in insulation, 167
- ASTM Committee C-16 on Thermal Insulation, 141, 212
- ASTM standards
  - B 117, 172
  - C 192, 160
  - C 234, 160
  - C 692, 29, 36
  - C 692-77, 211
    - problems with, 212-213
  - C 739, 141, 220-221, 225
  - C 871, 224
  - C 962, 221

- E 398, 22
- G 1, 225, 226
- G 26, 172

ASTM Subcommittee C16.3, Corrosion Task Group, 220, 221, 230

## B

- Bond strength and coatings, 159-161
- Borax, 139
- Boron, 226
- British Standard for Thermal Insulation Materials (BS 3958, Part 2), 190
- Bromides, 99, 100

## C

- Calcium silicate insulation, 17
  - corrosion under, 44-45
  - in high-temperature testing, 162-163
  - in hot service, 72
  - moisture absorption, 147
  - properties, 67
  - testing, 216-218
  - water extract, 46
  - water migration in, 200
- Capillarity, 7
- Carbon steel (*see* Steels, carbon)
- Cathodic protection, 138-139
- Caulking
  - breaks in, 36

- deteriorating, 88-89
- silicone, 100, 202, 203, 206
- Cellular glass (*see* Glass insulation, cellular)
- Cellulose Industry-Government Agencies Group, Ad Hoc, 223
- Cellulosic insulation
  - corrosiveness testing, 223
  - leachants, 224
  - moist, 139-140
  - moisture absorption, 221
- Cement, insulating, 168
- Chemical plants, corrosion experiences in, 86, 145-146
- Chemical Process Industries inspection methods study, 152
- Chiller water cooling/hot water heating system, 137-138
- Chloride ions, 7
  - stress corrosion cracking and, 8, 44
- Chlorides
  - concentration, 166, 200
  - density of deposits, 31
  - illustration, 30
  - from fire retardants, 66
  - in insulation, 31, 166, 178
  - in lagging, 48
  - protection against, 167
  - soluble, 189
  - sources of, 29-32, 48, 105
  - waterborne, 166
- Climate effects, 24, 149-150
- Coal tar epoxy coatings, 179
- Coating system for carbon/low alloy steel, 186
  - table, 187
- Coating system design, protective, 155
  - for insulating equipment, 156-157
- Coatings, 20-22
  - adhesiveness, 171, 172
  - anti-abrasion, 105, 110
  - applying, 108-110
  - before insulation, 153
  - cementitious, 45
  - in cracking prevention, 190
  - degradation, 21
    - illustration, 159
  - effectiveness, 113, 191-194
  - effects, 157
    - on bond strength, 159-161
  - evaluation, 157-158
  - failure, 20
  - flexibility, 171, 172
  - inorganic, zinc-rich (IOZR), 155, 157, 161
    - performance, 158
    - illustration, 159
  - organic, 34, 50-51
    - advantages, 155
  - permeability, 21, 34-35
  - specification, 179
  - for stainless steel, 168, 177
  - test programs for, 169-170
  - waterproof, 56
    - (*see also* Specific coatings and paints)
- Cold insulation systems, 117
- Cold piping system, 179
- Concrete
  - bonding, 159-161
  - coatings under insulation of, 157-164
- Condensation test, 225, 229
- Consumer Product Safety Commission, U.S., 141
- Copper corrosion products, 134, 137
- Copper chloride, 137
- Copper sulfate, 137, 138
  - illustration, 136
- Copper sulfide, 134
  - illustration, 136
- Copper water tube, aggressive insulation in, 132
- Corrosion
  - of copper, 133

- galvanic, illustration, 18
  - in liquefied petroleum gas tank, 114
  - Corrosion control
    - guidelines, 150-151
    - illustration, 152
    - under thermal insulation and fire-proofing, 58
  - Corrosion detection program, 73-74
  - Corrosion mechanisms, 131
    - in lagging, 56
  - Corrosion phenomena
    - in carbon/low alloy steels, 43-44
    - in stainless steels, 44-45
  - Corrosion prevention
    - in copper, 138-139
    - costs, 85
    - design, specification, inspection, and maintenance, 54-55
    - designing for, 178
      - features, 185, 186
      - steps in, 182-185
    - inhibited laggings, 48-50
    - organic coatings, 50-51
  - Corrosion rates of steel, 127, 131
  - Corrosion Science and Technology, Institute of, 43
  - Corrosion under insulation (CUI)
    - in carbon steel
      - contributing factors, 11, 156
      - illustration, 150
      - controlling, 145
    - in chemical plants, 86
    - critical areas, illustration, 80
    - design to prevent, illustration, 82-84
    - economics of, 154
    - examples, illustration, 75-77
    - extent of, 156
    - factors affecting, illustration, 147
    - in petrochemical plants, 71
    - reducing failures caused by, 204
    - of steel, 121
  - Corrosion under lagging, European meeting on, 42
  - Corrosiveness test methods, accelerated, 220
  - Cracking (*see* Stress corrosion cracking)
  - Cracking prevention policy, 190-191
- D**
- Dana test, 211
    - accelerated, 212, 216
  - Dryout, 14, 15
  - Dye checking, 89
    - illustration, 92
- E**
- Elastomer, flexible foamed, 66
  - Elastometric sealant, 96
  - Elcometer adhesion test, 171, 172
    - results, tables, 173-176
  - Embrittlement, liquid metal, 51, 191, 195, 198
    - incidence of, tables, 52, 53
  - Energy conservation, 5, 154
  - Engineering Task Force Group, 117
  - Environmental cabinet test, 172
    - results, tables, 173-176
  - Epoxy amine primer, 157, 163-164
  - Epoxy coatings, 50-51, 102
    - amine-cure, 157
    - application information, tables, 170, 171
    - effectiveness, 172
      - tables, 173-176
    - manufacturer's information, 169
    - permeability, 34-35
    - phenolic, 22, 108, 110-112, 123, 128, 163-164
      - effectiveness, 131
  - Epoxy system/epoxy phenolic, table, 187

Equipment design, 146, 147, 204  
 effects, 12  
 features, 148  
 Equipment painting, 156  
 Evaporation rate problems, 213  
 Exposure tests, carbon steel, 157

## F

Fabrication of materials, 52-54  
 Failure, stainless steel  
 explanation of, 100  
 investigation of cause, 96-99  
 prevention program, 100-102  
 Federal Standard Thermal Insulation  
 (Loose Fill for Pneumatic or  
 Poured Application): Cellu-  
 losic or Wood Fiber (HH-I-  
 515), 141  
 Fiberglass insulation, 19, 58  
 Fire protection deluge system, 100  
 illustration, 101  
 Fire retardants  
 additives, 221, 226  
 chlorides from, 66  
 compositions of, 140  
 table, 141  
 corrosivity, 139, 221, 226  
 halogenated, 47  
 mastic, 95  
 Fireproofed structures, protective  
 coating system design for, 155  
 Fireproofing  
 cementitious, 43  
 corrosion under, 44, 45-48, 156  
 Fire risks with aluminum foil, 194-  
 196  
 Foam glass, moisture absorption, 147  
 FOAMGLAS, 68  
 Foams  
 fire resistance, 65  
 organic, 47

phenolic, table, 47 (*See also* Epoxy,  
 phenolic)  
 (*see also* Polyisocyanurate foam;  
 Polyurethane foam)

## Foils

aluminum, 51, 57  
 applications and performance  
 of, 196-198  
 fire risk, 194-196  
 in stress corrosion cracking pre-  
 vention, 188  
 stainless steel, 51-52  
 Freezing effects on corrosion, 13-14

## G

Galvanic protection, 190-191, 194,  
 197  
 Glass insulation, cellular, 17, 45-46  
 blocks, 118  
 in cold insulation, 179  
 performance, 129  
 properties, 66  
 source of chlorides, 105  
 sources of sulfuric acid, 68  
 Glass-fiber insulation  
 corrosiveness testing, 223, 226, 229  
 properties, 66

## H

Halide ions, 7  
 leachable, 99, 100  
 table, 102  
 Halogenated flame retardants, 18  
 Heat flow control, 6  
 Heat loss, reduction, 5  
 Hot water heating/chilled water cool-  
 ing system, 137-138  
 Hot water lines, domestic, corrosion,  
 134-137  
 Humidity, sensitivity to, 18-19 (*see  
 also* Moisture; Vapor; Water)

Hydrogen sulfide, 17  
 Hygroscopicity, 7

## I

ICI lagging specifications, 191, 196  
 Icing in cold insulation, 181  
 Inhibitors, role of, 34-37  
 Inspection, 25, 58-59  
   functions of, 205-206  
   illustration, 26  
   programs, 146, 151-153  
   in reducing corrosion-induced failure, 204  
   techniques, 79-81, 206  
     costs, 85  
     nondestructive, 80  
 Insulated structures, protective coating for, 155  
 Insulating practice  
   changes in, 177  
   design basis, 166  
   installation, 168  
   materials, 167-168  
 Insulation  
   asbestos in, 167  
   blanket, 167  
   calcium silicate (*see* Calcium silicate insulation)  
   calcium silicate/magnesia, 43  
   cellulosic (*see* Cellulosic insulation; Glass insulation, cellular)  
   characteristics, 6, 16  
   closed pore (CPI), 29  
   chlorides in, 31, 166, 178  
   cold, 179  
     requirements, 180  
     signs of icing in, 181  
   corrosion under  
     controlling, 145  
     designing to prevent, 178  
     reducing failures caused by, 204

corrosiveness of, 15, 19, 133, 140, 141-142, 222  
   definition, 5, 58  
   design codes, 166  
   failure due to improper design and application, 201  
   function, 5  
   inhibited, 8, 107-108  
   inspection, 25, 58-59  
     illustration, 26  
     programs, 146, 151-153  
   installation, 206  
   leaching of, 147-148, 166  
   magnesia, 29  
   maintenance, 24-26, 150  
     illustration, 151  
   materials, 6, 168  
     aggressive, 133  
     cellulosic, 132  
     control of, 190  
     corrosive attack of, 133, 140, 141-142  
     natural carbonaceous granular, 132  
     recommended, table, 167  
   nonwicking, 200, 203  
   permeability, 23  
   for personnel protection, illustration, 16, 17  
   reflective, 6  
   selection, 15-20, 146-147, 179  
   stress corrosion cracking  
     of austenitic stainless steel under, 27  
     chloride, 165  
     prevention of, 55-56, 165  
   tarry asphaltic, 32  
   thickness, 160, 205  
     illustration, 206  
   water absorbancy, 15, 16, 147  
   wet, 12, 134, 204  
     corrosivity of, 45-48  
     resistivity of, 137

- wicking, 149, 189, 204
  - evaluation of, 211, 213
  - (*see also* Thermal insulation)
- Insulation specification
  - to avoid chloride stress corrosion cracking, 199
  - and guidelines, 146
- Insulation standards, revisions, to, 141
- “Insulation Works—Protection Against Corrosion for Cold and Hot Insulation at Industrial Plants,” 182

## J

- Jacketing
  - aluminum, 72, 167
  - corroded, illustration, 90, 93
  - leak point, illustration, 93
  - as moisture barrier, 201
  - perforated, 88, 92
  - broken, 12
    - illustration, 13
  - corrosion, 114
  - galvanized steel, 72
  - heat sealed moisture barrier, 179
  - installation, 167-168
  - metallic nonbreathing, 22
  - selection, 23
- Joint seals, prefabricated expansion/contraction, 184

## L

- Lagging
  - corrosion mechanism in, 56
  - corrosion under, 42
  - inhibited, 48-50
  - specification, 59
  - water in, 45, 52, 189, 197
- Leachant-coupon tests, 223, 225, 226, 229-230
- Lead chromate phenolic coating, 157

- Liquefied petroleum gas tank, shell and jacket corrosion, 114
- Liquid metal embrittlement, 51, 191, 195, 198
  - incidence of, tables, 52, 53
- Liquid penetrant inspection, 96
  - illustration, 97

## M

- Maintenance practices, 24-26
- Mastic
  - deterioration of, 24
  - fire retardant, 95
  - joint, 92
  - moisture intrusion and, 87
  - reinforced, 202
  - temperature limitations, 22
- Materials, changes in and corrosion, 156
- Materials Technology Institute (MTI)
  - corrosion studies, 122-123
  - inspection methods study, 152
- Mechanical design issues, 54
- Metallic foils, 51-52 (*see also* Aluminum foil)
- Metallic paints (*see* Paints, metal-filled)
- Military Specification Insulation Materials, Thermal, with Special Corrosion and Chloride Requirements (MIL-24244), 35, 178, 213
- Mineral wool, 19, 46
  - corrosiveness testing, 223, 226, 229
  - in hot and cold service, 72
  - performance, 129
  - properties, 66-67
- Moisture
  - atmospheric, 28, 29, 32
  - barrier, 199 (*see also* Vapor barriers)
  - as cause of corrosion, 204
  - intrusion points, 87, 88

penetration, 119, 120  
 prevention of, 115, 179-180,  
 200  
 resistance, 7

## N

National Board Inspection Code, 26  
 Nozzles, Type 316 stainless steel,  
 failure of, 95

## O

Oleoresinous coating, 163-164  
 Outdoor exposure test, 171-172  
 results, tables, 173-176  
 Oxide film formation, 124, 127  
 in stainless steels, 168-169

## P

Painting  
 criteria, 108-110  
 effects on corrosion, illustration,  
 77  
 Paints  
 metal-filled, 51-52, 191  
 protection, 146  
 (*see also* Coatings)  
 Perlite insulation, types of, 129  
 Perlite-silicate, 67  
 Petrochemical plants, corrosion  
 problem, 71  
 Phenolic lead chromate primer, 163-  
 164  
 Pitting, 38, 126  
 of carbon steel, 43  
 of expanded perlite, 129  
 of stainless steel, illustration, 91  
 Plant conditions, 24, 72-73  
 Polyisocyanurate foam, 200, 201  
 rigid, 65-66  
 Polyurethane foam (PUF), 18-19,  
 21, 45, 64-65, 72

corrosion under, illustration, 21  
 fire retardant, 115  
 application, 120  
 in high-temperature testing, 163  
 leaching of, 119  
 water saturation, 116  
 lagging, 45  
 rigid, 65  
 water extract properties, table, 47  
 Polyvinyl chloride (PVC)  
 breakdown, 31-32  
 source of chlorides, 105  
 Potential, role of, 34-37  
 Pressure vessels, corrosion, table, 79  
 Protective barrier, failure of, 11

## R

Rainwater  
 sodium chloride in, 24, 28-31  
 illustration, 29  
 pH of, 28  
 source of moisture, 124  
 (*see also* Runoff)  
 Red lead alkyd, 157  
 Refining and petrochemical industry  
 plants, 122  
 Research, Development, Test, and  
 Evaluation (Navy) Test Re-  
 quirements for Thermal Insu-  
 lating for Use on Austenitic  
 Stainless Steel (M12-1T), 212  
 Runoff, 32, 36  
 Rusting, 115  
 bonding and, 161  
 breakthrough, illustration, 115, 117  
 under cement, 158

## S

Salts (*see* Sodium chloride)  
 Scratch test, 171  
 results, tables, 173-176  
 Seawater deluge, 116

- Shell corrosion, 114
- Silicon, 39
- Silicone acrylic primer, 163-164
- Silicone-aklyds, 50
  - testing results, 192-193
- Silicone coatings, 108, 110, 111
  - application information, tables, 170, 171
  - effectiveness, 172
    - tables, 173-176
  - manufacturer's information, tables, 169, 170
- Silicone paint, aluminum filled, 193
- Sodium chloride
  - airborne, 28
  - concentration, 15, 24
  - deposits, 33
  - hygroscopic, 33, 36, 40
  - in rainwater, 28-31
    - illustration, 29
- Sodium metasilicate inhibitors, 35, 36, 37, 39
- Sodium silicate insulation, 7
  - application to steel, 49
  - in chemical plants, 87, 89
  - inhibiting action, 200
  - leaching, 88, 89, 94
- Spectrometer analysis, table, 100
- Steel Structures Painting Council
  - SSPC-5, 157, 168
  - SSPC-6, 157
- Steels
  - austenitic, 166
    - characteristics, 7
    - insulation used with, 167
    - protection, 7
    - shortcomings, 8
    - stress corrosion cracking, 27
      - prevention, 188
      - "super" (20 Cr 25 Ni), 53-54
    - susceptible materials, 38-39
  - carbon, 38
    - corrosion under thermal insulation
      - controlling, 145
      - factors affecting, 11
    - equipment, 156
    - scaling and pitting, illustration, 94
  - carbon/low alloy
    - corrosion phenomena, 43-44
    - surface preparation and coating system, 186-187
  - corrosion under thermal insulation materials, 121
  - duplex stainless (18 Cr 5 Ni), 53
  - extra low interstitial ferritic (18 Cr 2 Mo), 53
  - SAE 1010, 225, 226
  - stainless
    - AISI Type 304, 38, 39, 50, 74, 87
      - exposure testing, 172
      - stress corrosion cracking in, 104, 106
        - tables, 193, 194
    - AISI Type 316, 38, 56, 74, 87
      - failure, 95
      - coatings for, 168-177
  - corrosion phenomena, 44-45
    - 18Cr 8 Ni, 168
    - environment, under insulation, 28
    - external stress corrosion cracking, 103
    - failure categories, illustration, 46
    - mechanical bonding, 169
    - vessels, illustration, 90-91
- Stress corrosion, chloride induced, 7
- Stress corrosion cracking
  - of austenitic stainless steels
    - factors, affecting, 27
  - chloride, 29, 68, 100
    - mechanism of, 166
    - prevention of, 165
    - specifications to avoid, 199
    - transgranular, 28, 38-39

- external (ESCCC), 27, 31, 39-40
    - of carbon steels, 44
    - effects of surface treatment, table, 218
    - fire risks in, 195
    - induction of, 199
    - prevention of, 103-104, 191
    - in process industries, 188-189
    - stainless steel under thermal insulation, 103
  - intergranular, 38
  - under insulation, 8, 103
  - mechanisms of, 7
  - temperature ranges for, 37-38
  - transgranular, 28, 38-39, 104
  - Stress corrosion cracking prevention
    - aluminum foil use for, 188
    - under lagging, 57
    - materials fabrication/selection, 52-54
    - metallic foils/paints, 51-52
    - program, 100-102
  - Stress corrosion cracking tests, 211
  - Sulfur dioxide concentrations, 28
  - Surface preparation for carbon/low alloy steel, 186-187
- T**
- Temperature(s)
    - coating failure and, 161-163
    - control, 5
    - fluctuation reduction, 5
    - problems, 212-213
    - service
      - cold, 72
      - corrosion-prone, 74
      - effects of, 13-15
      - hot, 72
      - recommended, table, 64
    - for stress corrosion cracking, 37-38
  - Tests
    - accelerated corrosiveness methods, 220
    - condensation, 225, 229
    - Dana, 211
      - accelerated, 212, 216
    - Elcometer Adhesion, 171, 172
      - results, tables, 173-176
    - environment cabinet, 172
      - results, tables, 173-176
    - high-temperature cyclic, 161-163
      - results, table, 164
    - leachant-coupon, 223, 225, 226, 229-230
    - outdoor exposure, 171-172
      - results, tables, 173-176
    - salt fog, 172
      - results, tables, 173-176
    - scratch, 171
      - results, tables, 173-176
    - stress corrosion cracking, 211
    - voltammetry, 223, 224, 226, 229-230
    - weatherometer, 172
      - results, tables, 173-176
  - Thermal insulations
    - accelerated corrosiveness test methods for, 220
    - carbon steel corrosion under, factors affecting, 11
    - characteristics of, 6
    - corrosion in petrochemical plants, 71
    - defined, 5
    - function, 5
    - inhibition of, 8
    - materials and composition, 6
    - prevention of stress corrosion cracking under, 188
  - Thermal Insulation Manufacturers' and Suppliers Association, 143
  - Thermal insulation materials
    - contribution to corrosion, 67

- generic types and properties, 63
- k* values, tables, 64, 65
- selection, 67
- service temperature ranges, 64
- Thermal insulation systems for hot and cold service, 72
- Thermal Insulation Users Liaison Group (UK), 42
- Thermal shock test, 172
  - results, tables, 173-176

## U

- Union Carbide Gulf Coast plants, 104, 122
- Urea formaldehyde (UF) foam, corrosiveness testing, 223
- Urethane in cold insulation, 179

## V

- Vapor, 6
  - barriers, 18, 179
  - injury to, 180
  - purpose, 22
  - condensation, prevention of, 5
  - retarders, 7
  - transmission rate, 7
  - (*see also* Moisture; Water)
- Vaporproofing, 22-24
  - design, 149
  - (*see also* Waterproofing)
- Vinyl coatings, tables, 169, 170
  - application information, tables, 170, 171
  - effectiveness, 172
  - tables, 173-176
- Voltammetry, 223, 224, 226, 229-230

## W

- Water
    - absorbance (*see* Insulation)
    - cooling tower, 24
    - corrosivity of, 11, 18
    - drainage, 149
    - electrolytes in, 28
    - ingress
      - flooding, 189, 190, 191, 197
      - migration, 189, 190, 191, 197
      - protection against, 198
    - sources of, 32-33
    - trapped, illustration, 75
    - as vapor, 6, 7
    - (*see also* Moisture; Vapor)
  - Waterproofing, 54
  - Weather barriers, 32
    - aluminum, 115, 123
    - breakdown of, 33
    - effectiveness, 131
    - evaluation, 200
    - on irregular shapes, 202
    - purpose, 22
  - Weatherometer tests, 172
    - results, tables, 173-176
  - Weatherproofing, 22-24
    - design, 149
  - Weathershed ring, 204
    - illustration, 205
  - Wet exposure cycle characteristics, 11
  - Wicking, 149, 189, 204
    - evaluation of, 211, 213
- Z**
- Zinc-rich paints, 51, 57
    - efficiency of, 198
    - incidence of cracking in, 194
    - inorganic, 155, 157-159, 161