APPENDIX A

References


Reference materials for further reading regarding tire chemistry, tire mechanics, and tire inspection are as follows:


McClain, Calvin P. and DiTallo, Michael, A., “Tire Examination After Motor Vehicle Collisions,” in Baker, Kenneth, Traffic Accident Collision Investigation,
References


Abnormal wear, 110
Accelerated wear, 23, 24f, 29–33
Abrasions, 12, 21–23, 86
   bead face, 66
   circumferential, 124
   identification of, 102–104
Air leakage into the casing, 43
Alignment, 11, 122, 148
ASTM D-1149, 90n
ASTM D-2229-04el, 153n
Balance weight clip marks, 174
   chattering of, 63–64, 139, 140f
   significance of, 137–144
Beach marks, 20–21
Bead
   breaks in, 116, 117f
   creel-type, 116
   inspection of, 166–167
   creased or cracked, 64–65
   separations of, 112–117
   tears of, 51, 93–98
Bead face
   abrasion of, 66
   circumferential line in, 66, 82
Bead wires, tensile breaks of, 117f
Belt compound, fractured, 81
Belt edge, and high temperature, 108–109
Belt edge gum strip, 3–4, 35–36
Belt edge separation (BES), 35–37
Belt package, 2, 3f
   probing for, 69
Belt separations, 1–13
   accelerated wear and, 29–33
   additive effects causing, 34
   atypical, 37–38
   causes of and contributors to, 6–13,
   39–110
   abrasions, 102–104
   cuts, 87, 102–104
   cutting and chipping (C&C),
   104–106
   demounting damage, 51, 93–98
   gouges, 72f, 102–104
   high speed, 108–109
   high temperature, 107, 109–110
   impacts, 51, 73–88
   mounting damage, 51, 93–98
   maintenance, improper, 45–46,
   107–108
   over-deflection, 56–67
   ozone deterioration, 76, 77f, 88–93,
   100–101
   punctures, 39–56
   penetrations, 67–73
   physiological aging, 98–101
   snags, 102–104
   storage, improper, 106–107
Belt separations (continued)
causes of and contributors to (continued)
tears, 102–104
vehicle-related conditions, 109–110
“clean,” 78n
cumulative damage and, 33–34
edge, 35–36
incipient, 37
identification of, 15–34
interfacial, 38
localized, 81–82
parabolic form of, 2f, 4, 5–6, 15
root causes of, 6–13
and run-flat, 121
top belt and tread intact
interior characteristics, 26–29
tread and belt detached, 15–23
Belt skim stock, 3
Belt wires, 45
   brassy wire failure, 151–154
   breakage of, 55–56, 70, 87
      flex, 27, 29f, 87
      tensile, 27, 28f, 87
   cut, 30f, 87
   ozone deterioration in, 93f
Belts, inspection of, 168–169
Bluing, 15, 17f, 18f, 21, 56, 58n, 59, 66, 108f
Bonding, 152
Brake drag, 110
Braking, hard, 139
Brassy wire failure, 151–154
Brittle appearance, 18, 66f
Bubbles, 26
Bulges, 23, 25f
   non-ozone-related, 129–130
Butt splice, appearance of, 131
Camber wear, 147–148
Cap ply, 156–157
Center wear, 147, 148f
Centrifugal force, 8, 30
Chafer, 115
Chemical damage, 124–125
Chipper, 115
Chipping, and cutting, 104–106
Circumferential tearing, 50f, 101
Clip marks
   balance weight, 63–64, 137–144
   wheel weight, 61–62, 137
Clock face nomenclature, 161
Compression grooves (CG), 124, 126, 166–167, 197
   and balance weight clip marks, 137–139
   characteristics of, 198
   examples of, 198–201
   observation of, 56–58, 61–62
Cord shadowing (CS), 133, 134, 135f
Cord through liner (CTL), 133n
Crack growth, 1–2, 42–45
Crack initiation, 1, 3–6, 13, 42–45, 56, 105
Crack propagation, 1, 3–6, 42–45
Cracks
   circumferential, 56
      at edge, 20
      flow, 112, 113f
      of interior bead toe, 64–65
      non-ozone-related, 125–126
      torque, 123
      in tread, 23, 25f
Cross-hatching, 99, 100f
Curbing, 145–146, 147
Curing, 1n
Cuts, 12
   identification of, 87, 102–104
   from mounting/demounting, 93
   wheel flange, 98
Cutting and chipping (C&C), 104–106
Damage trail, 79
Deflection, 7f
  normal, 6
  over-deflection, 6–7
Demounting, damage from, 11
  identification of, 51, 93–98
Design conditions, 13
Dry rot See Ozone deterioration
Durometer, 98–99, 107

ECE R30, 7
Edge cracking, 20
Elasticity, 99–100
Ethylene propylene diene monomer (EPDM), 91

Federal Motor Vehicle Safety Standards (FMVSS), 2n
Field examination, 159
Fishbone diagram, 167
Flex wire breaks, 27, 29f, 87, 108
Flow cracks, 112, 113f
Fluorescent light, 128
Front tires, 148–149

Glass transition temperature, 153
Glossary, 185–195
Gouges, 12
  identification of, 72f, 102–104
H block pull-out test, 153
Hardness values, 98–99
Heel and toe, 148, 149
High speed, identification of, 108–109
High temperature, identification of, 107, 109–110
Holography, 2

Impacts, 8, 46, 51
  identification of, 73–88
  and run-flat, 122
  sharpness of fracture area, 87
  time to failure, 73, 75–76
Inboard side vs. outboard side, determining, 145–147
Incipient belt edge separation, 37
Indentations, non-ozone-related, 126–128
Inflation, 6
Innerliner, 11, 27, 41, 51, 52–53
  deformation of, 82–83
  discoloration of, 58–59
  identification of conditions of, 130–135
  identification tags on, 132
  manufacturing imprints on, 154–156
  openings in, 132–134
  ply cord shadowing in, 134, 135f
  radial split in, 86–87
  split in, 49f
  wrinkling of, 58, 59f
Inspection, 39n
  basic, 159–161
  marking for, 161–163
  note taking during, 160, 163–165
  process for, 163–165, 169–170
  by shadows, 163
  tactile, 165–169
  visual, 165–169
  wheel, 170–173
Interfacial belt separation, 38
Intra-car cass pressurization (ICP), 11, 43, 47–53, 86–87, 101, 134
Irregular wear, 31, 108
Laboratory examination, 159
Lap splice, appearance of, 130–131
Left side vs. right side, determining, 149–150
Liner See Innerliner
Liner marks, 154–156
Localized treadwear, 23, 24f
Luminosity, 18, 56

Maintenance, improper, 45–46, 107–108
Mal-design, 13
Mal-manufacturing, 13
Malwear, 10, 110
Manufacturing conditions, 13
Manufacturing imprints, 154–156
Medium/heavy truck tires, 65n
Modern radial tires, 1
Mounting
  damage from, 11, 51, 93–98
  multiple mountings, 139
  tactile inspection, 165–169
  visual inspection, 165–169
  wheel inspection, 170–173
  x-rays, 54–55, 73, 129
Nylon overlay, 156–158
Opposite serial side (OSS), 164, 167
Outboard side vs. inboard side, determining, 145–147
Over-deflection, 6–7
  identification of, 56–67
  and tire storage, 106
Overlay, nylon, 156–158
Overload, 6
Oxidation, 9, 50, 52, 86, 101
Ozone deterioration, 9, 105, 145
  identification of, 76, 77f, 88–93, 100–101
  Shell rating scale for, 165n, 209–210
  and tire storage, 106
Penetrations, 12–13, 105
  identification of, 67–73
Petroleum products, damage from, 106–107, 124–125
Photographs, 159–160, 163–165, 166, 177
Physiological damage, 9–10
  identification of, 49f, 51, 98–101
Ply cords, 11
  broken, 87, 129f
  shadowing of, 133, 134, 135f
  fluffing of, 46, 47f, 73, 74f
  separation between, 117–118
Polishing, 15, 16f, 17f, 18, 21
Pressure gradient, 51
Probing, 39, 41, 69
Punctures, 80f, 82, 105
  identification of, 39–56
  improperly repaired, 10
Nondestructive investigation techniques, 159–177
  fluorescent light, 128
  holography, 2
  identifying rebalances, 176–177
  inspection procedure, 159–161, 163–165, 169–170
  marking for inspection, 161–163
  matching wheel to tire, 174–175
  photographs, 159–160, 163–165, 166, 177
  shearography, 2, 128
National Highway Traffic Safety Administration (NHTSA), 98n, 107, 161n
Noise, increased, 5n
Non-belt separations
  bead, 112–117
  sidewall, 117–118
  tread, 111–112
Nondestructive investigation techniques, 159–177
  fluorescent light, 128
  holography, 2
  identifying rebalances, 176–177
  inspection procedure, 159–161, 163–165, 169–170
  marking for inspection, 161–163
  matching wheel to tire, 174–175
  photographs, 159–160, 163–165, 166, 177
  shearography, 2, 128
Penetrations, 12–13, 105
  identification of, 67–73
Petroleum products, damage from, 106–107, 124–125
Photographs, 159–160, 163–165, 166, 177
Physiological damage, 9–10
  identification of, 49f, 51, 98–101
Ply cords, 11
  broken, 87, 129f
  shadowing of, 133, 134, 135f
  fluffing of, 46, 47f, 73, 74f
  separation between, 117–118
Polishing, 15, 16f, 17f, 18, 21
Pressure gradient, 51
Probing, 39, 41, 69
Punctures, 80f, 82, 105
  identification of, 39–56
  improperly repaired, 10
Index

intra-carcass pressurization, 47–53
probing of, 39, 41
and run-flat, 122
unrepaired, 10, 40f
wedge-shaped, 43f

Radial tires, modern, 1
Rear tires, 147–148
Rebalancing, 139, 140
   identifying, 176–177
Removal from service, 9–10
Repairs, improper, 45, 51
Reverse bead angle, 65
Reversion, 15, 21
Right side vs. left side, determining, 149–150
Rim fitments, 64n
Rim flange, 171, 172, 173
   bending of, 83, 85
Rim pinch, 122, 123f
RMA, 46
Road hazards See Impacts
Road rash See Abrasions
Rough texture, 18, 21
Rubber
   characteristics of, 89–91
   thick/thin, 19–20
Rubber Manufacturers Association (RMA), 10, 107
Run-flat damage, 119–124
Run-flat sequence, 203–207
Rust, 43–45, 53–55, 71–73

Sidewalls
chemical damage to, 124–125
cracking in, 90, 126
creasing in, 91
damaged, 82
detached, 50–51, 83, 84f, 87
exterior, contact with road surface, 59–60
fractured, 76–80
indentations in, 126
oval area in, 83
ozone deterioration in, 88f
scuffing from curbing, 145–146, 147
separation of, 114, 117–118
serial side, 161, 165–166
spare tire marks on, 126, 128
spot ozone damage of, 101f
white, 91, 92f, 118, 126
Siping, 32, 33
Snags, 12
   identification of, 102–104
Spare tire marks, 126, 128f
Speed, high, 7–8
   identification of, 108–109
Speed rating, 7
Splice locations, openings at, 132–133
Squirming, 30
Standing wave effect, 108
Stop/start marks, 20–21
Storage, 11–12, 54, 72–73, 91, 100
   improper, identification of, 106–107
Strain, 90
Sunlight, exposure to, 91, 106
Suspension, poor maintenance of, 11

SAE 1561/1633, 7
Safety belts, 157
Salt corrosion, 42, 45, 53–55
Scaling, 56
Serial side (SS), 161, 165–166
Shearography, 2, 128
Shell rating scale, 165n, 209–210

Tactile inspection, 165–169
Tears, 12
   bead, 51, 93–98
circumferential, 50f, 101
directional, 104f
   identification of, 102–104
short, 15, 16f, 18, 21, 47
Tears (continued)
  wheel flange, 98
Temperature
  ambient, 8
  glass transition, 153
  internal, 7
  pavement, 8
Tensile wire breaks, 27, 28f, 87, 108, 117f
Thick/thin rubber, 19–20
Tire and Rim Association (TRA), 6, 64n
Tire Industry Association (TIA), 107
Tires
  aging of, 9–10
  building process for, 154
  demounting from wheel, 169–170
  location on vehicle, 145–150
  maintenance of, 10–11
  matching wheel to, 174–175
  medium/heavy truck, 65n
Torque cracks, 123
Tourniquets, 157
Transition zone, 20
Tread
  attached to casing, 67–70
  and belt detachment, 15–23, 70–73
  chemical damage to, 124–125
  cracking of, 23, 25f
  creasing of, 66, 67f
  cutting and chipping of, 104–106
  damaged, 82
  depth of, 168
  fractured, 76–80
  inspection of, 60–61, 167–168
  irregular wear of, 108
  odd appearance of, 26
  separations of, 111–112
Under-inflation, 6
U.S. Department of Transportation (DOT), 2, 158
Valve
  defective, 122
  location of, 170
Vibration, 5–6
Visual inspection, 165–169
Water corrosion, 42, 43, 45, 53–55
Wear
  abnormal, 110
  accelerated 23, 24f, 29–33
  irregular, 31, 108
Weather checking See Ozone deterioration
Wheel weight clip marks, 140–142, 171, 174, 176
  vs. balance weight marks, 137
  depth of, 61–62
Wheels
  damaged, 122
  demounting tire from, 169–170
  matching to tire, 174–175
  flange damage, 95
  inspection of, 170–173
  taper angle of, 64–65
Whitewalls, 91, 92f, 118, 126
“X” pattern, 76, 78, 150
X-rays, 54–55, 73, 129
About the Author

Thomas Giapponi received his B.S.E. from Purdue University in 1976. He is a registered Professional Engineer (Connecticut) with more than 30 years of experience in the tire industry. Mr. Giapponi’s professional career spans the Armstrong Rubber Company and Pirelli Tire North America in the capacities of Tire Design Engineer; Manager of Medium/Heavy Truck Tires; Manager of Light Truck and Passenger Car Tire Engineering; Director of Tire Engineering; and Director of Tire Testing. At Pirelli’s tire manufacturing plant in Hanford, California, Mr. Giapponi directed Pirelli’s North American research and development and quality as the Director of R&D, Technical Director, and the Director of Quality in the market, respectively.

In 2001, Mr. Giapponi started TRGtech Tire Consulting LLC (www.tireconsultant.com). The company performs tire forensic investigations and tire patent defense, in addition to tire and tire forensic analysis training and consulting.

Mr. Giapponi also is a member of SAE International and the Tire Society, and he is Past President of the Tire and Rim Association.