THE RUBBER FORMULARY

by

Peter A. Ciullo
R.T. Vanderbilt Company, Inc.
Norwalk, Connecticut

Norman Hewitt
PPG Industries, Inc.
Pittsburgh, Pennsylvania

np
NOYES PUBLICATIONS
Norwich, New York, U.S.A.

pdl
Plastics Design Library

Library of Congress Catalog Card Number: 99–26196
ISBN: 0–8155–1434–4
Printed in the United States

Published in the United States of America by
Noyes Publications/William Andrew Publishing, LLC
13 Eaton Avenue, Norwich, New York 13815

10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Ciullo, Peter A, 1954–
The rubber formulary *I* by Peter A Ciullo and Norman Hewitt.
p. cm.
Includes bibliographical references.
ISBN 0–8155–1434–4
1. Rubber chemistry. 2. Chemistry, Technical--Formulas, receipts, prescriptions. I. Hewitt, Norman. II. Title.
TS1890.C58 1999
678' .2--dc2l

99–26196
CIP

For

Claudia, Marissa and Adam
PAC

Ruth and Max
NH

NOTICE

CONTENTS

RUBBER 1
INTRODUCTION 1
COMPOUNDING MATERIALS 4
RUBBER PROCESSING 49
PHYSICAL TESTING OF RUBBER 55
NATURAL RUBBER, POLYISOPRENE 73
TIRE CARCASS COMPOUND 74
TIRE BLACK SIDEWALL COMPOUND 75
TIRE COVER STRIP COMPOUND 76
TIRE CHAFER/RIM FLANGE COMPOUND 77
TIRE BEAD FILLER/APEX COMPOUND 77
TIRE BELT SKIM COMPOUND 79
TIRE BASE TREAD 81
AGRICULTURAL SEMI-PNEUMATIC TIRE 83
MOTOR MOUNT 84
WIPER BLADE 85
PIPE GASKET 86
PIPE GASKET 87
POLYISOPRENE SEAL 88
FOOTWEAR FOXING OR TOE CAP COMPOUND 89
EXTRUSION COMPOUNDS 90
CONVEYOR BELT COVER 91
BRIDGE BEARING PAD 92
BLOWOUT PREVENTER 93
PHARMACEUTICAL BOTTLE STOPPER 94
RUBBER BAND 95
RUBBER SPRING 96
RACQUET BALL 97
RUBBER THREAD 98

TRANSLUCENT ARTICLE 99
HIGH RESILIENCE COMPOUND 100
DUROMETER 40 COMPOUND FOR TEAR STRENGTH 101
DUROMETER 45 COMPOUND FOR MOTOR MOUNT 102
DUROMETER 55, OZONE RESISTANCE, HANDLE GRIP 102
DUROMETER 55, OZONE RESISTANCE, HANDLE GRIP 103
DUROMETER 60 COMPOUND FOR LOW COST 104
DUROMETER 60, HEAT RESISTANCE & TEAR STRENGTH 105
DUROMETER 60, TEAR STRENGTH, LOW HEAT BUILD-UP 106
DUROMETER 64, LOW ROLLING RESISTANCE TRUCK TREAD 108
DUROMETER 65 COMPOUND FOR BRASS ADHESION 110
DUROMETER 65 COMPOUND FOR LOW HEAT BUILD-UP 111
DUROMETER 65 COMPOUND FOR THICK ARTICLES 112
DUROMETER 70 COMPOUND FOR EXERCISE BAND 114
DUROMETER 75 COMPOUND FOR BUSHINGS 115
DUROMETER 77 COMPOUND FOR REVERSION RESISTANCE .. 116
DUROMETER 80 COMPOUND FOR SOLING 117
DUROMETER 80 COMPOUND FOR FIBER REINFORCED 119
DUROMETER 93 COMPOUND FOR EASY PROCESSING 120
STYRENE-BUTADIENE, POLYBUTADIENE 121
SBR SEAL 122
TREAD RECIPE 123
TIRE TREAD RECIPE 124
TREAD RECIPE 125
TREAD STOCK 126
DUROMETER 62 COMPOUND FOR LT TREAD 127
DUROMETER 65 COMPOUND, HIGH PERFORMANCE TREAD .. 129
DURO 68, LOW ROLLING RESISTANCE PASSENGER TREAD.... 131
DUROMETER 70 COMPOUND, HIGH PERFORMANCE TREAD .. 132
DUROMETER 74, WET TRACTION, TEAR STRENGTH 134
TIRE TOE STRIP COMPOUND 136
DUROMETER 90 COMPOUND FOR ROLLS 137

DUROMETER 93 COMPOUND FOR ROLLS 138
CREPE SOLE FORMULATIONS 139
SOLE FORMULATIONS 140
CELLULAR SHOE SOLING 141
CELLULAR SHOE SOLING 142
CELLULAR SHOE SOLING 143
TEAR AND ABRASION RESISTANT SOLING 144
DUROMETER 48 COMPOUND FOR FOOTWEAR 145
DUROMETER 60 COMPOUND FOR FOOTWEAR 146
DUROMETER 62 COMPOUND FOR FOOTWEAR 147
DUROMETER 64, ABRASION RESISTANCE, FOOTWEAR 148
DUROMETER 65 COMPOUND FOR FOOTWEAR, ZINC-FREE 149
DUROMETER 68 COMPOUND FOR TRANSLUCENT SOLING 150
DUROMETER 70 COMPOUND FOR SHOE SOLES 151
DUROMETER 70 COMPOUND FOR SOLING 152
DUROMETER 80 COMPOUND FOR FOOTWEAR 153
DUROMETER 85 COMPOUND FOR SOLING 154
CONVEYOR BELT COVER 155
FRICTION AND SKIM COAT FORMULATIONS 156
GOLF BALL CORES 157
DAMPENING COMPOUND 158
SBR EXTRUSION COMPOUNDS 159
HARD RUBBER FORMULATIONS 160
DUROMETER 64 COMPOUND FOR ABRASION RESISTANCE 161
DUROMETER 70 COMPOUND FOR ABRASION RESISTANCE 162
DUROMETER 73 COMPOUND FOR ABRASION RESISTANCE, ... 163
DUROMETER 75 COMPOUND FOR ABRASION RESISTANCE 164
DUROMETER 80 COMPOUND FOR ABRASION RESISTANCE 165
COMPOUND FOR TEAR STRENGTH, ABRASION RESISTANCE 167
DUROMETER 60, RAPID CURE, LOW HEAT BUILD-UP 168
DUROMETER 65, LOW SET & LOW HEAT BUILD-UP 169
DUROMETER 65 COMPOUND FOR TRANSLUCENCE 170

DUROMETER 65 COMPOUND FOR TRANSLUCENCE 172
DUROMETER 70 COMPOUND, NON-DISCOLORING 173
DUROMETER 70 COMPOUND FOR SEMI-OIL RESISTANCE 174
DUROMETER 80, LOW SET, NON-TRANSLUCENT 175
DUROMETER 90 COMPOUND FOR FLOORING 177
NATURAL RUBBER/BUTADIENE BLEND...............................178
PRESS MOLDED CLOSED CELL SHEET SPONGE.....................179
PRESS MOLDED CLOSED CELL SHEET SPONGE,
NON-OIL RESISTANT..180
PRESS MOLDED CLOSED CELL SHEET SPONGE.....................181
PRESS MOLDED CLOSED CELL SHEET SPONGE.....................182
BUTYL, HALOBUTYL...183
BROMOBUTYL HIGH TEMPERATURE HOSE..........................184
CHLOROBUTYL STEAM HOSE COMPOUND – TUBE 185
STEAM HOSE TUBE...186
DUROMETER 65 COMPOUND FOR STEAM HOSE 187
HEAT-RESISTANT CONVEYOR BELT 188
CHLOROBUTYL COVER COMPOUND FOR CONVEYOR BELT..189
BROMOBUTYL CONVEYOR BELT COVER 190
TIRE WHITE SIDEWALL COMPOUND 191
TIRE INNERLINER COMPOUND 192
CHLOROBUTYL INNERLINER COMPOUND 193
BROMOBUTYL INNERLINER COMPOUND.............................194
INNERLINERS 195
INNERLINER...196
CHLOROBUTYL EXHAUST HANGER COMPOUND...................198
DUROMETER 45 COMPOUND FOR SQUASH BALLS 199
CHLORINATED BUTYL PHARMACEUTICAL CLOSURE 200
BROMOBUTYL PHARMACEUTICAL CLOSURE......................201
DUROMETER 55 COMPOUND FOR GENERAL MRG 202
LOW RESILIENCE COMPOUND...204
HIGH HARDNESS COMPOUND 205

NEOPRENE....207
AIR CONDITIONER HOSE....208
DUROMETER 65 COMPOUND FOR HOSE 209
DUROMETER 63 COMPOUND FOR HOSE 210
DUROMETER 80 COMPOUND FOR HOSE, BRASS ADHESION 212
DUROMETER 70 COMPOUND FOR HOSE, SURFACE GLOSS....213
NON-BLACK HOSE COVER....214
DUROMETER 75 COMPOUND FOR BELTS....215
V-BELT RECOMMENDATION....216
NEOPRENE SEAL 217
DUROMETER 40 COMPOUND FOR ROLLS & GASKETS....218
NEOPRENE ROLL COMPOUND 219
AIR SPRING 220
STARTING POINT FORMULATION FOR WET SUIT....221
EXTRUSION COMPOUND, MICROWAVE CURE....222
EXTRUSION COMPOUNDS....223
FORMULATIONS FOR MILITARY APPLICATION 224
FLAME RESISTANT BRIDGE BEARING PAD 225
HIGH HARDNESS COMPOUND 226
DUROMETER 67 PLY SKIM FOR RFL FABRIC AND CORD....227
DUROMETER 60 COMPOUND FOR PLY ADHESION 228
DUROMETER 53 COMPOUND FOR PLY ADHESION 229
DUROMETER 70, TEXTILE ADHESION & MILL RELEASE....230
DUROMETER 70 COMPOUND FOR LOW SET 231
DUROMETER 70, SEMI-CONDUCTIVE/DIRECT BONDING....232
DUROMETER 80 COMPOUND FOR ADHESION....234
DUROMETER 60, TEAR STRENGTH & HEAT RESISTANCE 236
DUROMETER 70, TEAR STRENGTH & HEAT RESISTANCE 237
DUROMETER 65 COMPOUND FOR ABRASION RESISTANCE....238
PRESS MOLDED CLOSED CELL SHEET SPONGE....239
CELLULAR SHOE SOLING....240

EPDM **241**
COOLANT HOSE 242
AUTOMOTIVE RADIATOR HOSE 243
RADIATOR HOSE 244
RADIATOR HOSE 245
SAE J20R, CLASS D-3 SPECIFICATION COOLANT HOSE 246
SAE J20R, CLASS D-1 SPECIFICATION COOLANT HOSE 248
AIR BRAKE HOSE 250
AIR CONDITIONING HOSE COVER COMPOUND 251
HYDRAULIC HOSE TUBE FOR PHOSPHATE ESTERS 253
HIGHLY EXTENDED HOSE 255
STEAM HOSE TUBE 256
STEAM HOSE 257
NON-BLACK, FLAME-RESISTANT COVER 258
LOW COST, NON-BLACK COVER 259
GENERAL PURPOSE HOSE COMPOUND 260
HIGH QUALITY HEAT RESISTANT HOSE 262
VACUUM TUBING 263
GARDEN HOSE TUBE COMPOUND 264
COVER COMPOUND FOR WIRE BRAID HOSE 266
HEAT RESISTANT BELT COVER 268
HIGH TEMPERATURE RESISTANT TRANSMISSION BELT 269
AUTOMOTIVE WINDOW GASKETS 270
WINDSHIELD GASKETS 272
AUTOMOTIVE WEATHERSTRIPS 273
EPDM SEAL 274
GENERAL GASKET 275
WASHING MACHINE GASKET 277
CHLORAMINE RESISTANT COMPOUND 279
FOR MOLDED GASKETS, SEALS, MEMBRANES 279
BUILDING SEALS 280
CURTAIN WALL SEAL 281

LATHE CUT WASHER 282
GENERAL WEATHER-STRIPPING 283
LINESMAN BLANKET CALENDERING COMPOUND 285
UV RESISTANT WHITE SHEET 286
ROOF SHEETING 287
SINGLE PLY ROOFING COMPOUND 289
FLAME RETARDANT SHEETING, MOLDING APPLICATIONS 290
MOTOR LEAD WIRE INSULATION 291
IGNITION CABLE INSULATION 292
IGNITION WIRE INSULATION 293
LOW COST ELECTRICAL INSULATION 295
MEDIUM-HIGH VOLTAGE INSULATION 296
FLEXIBLE CORD INSULATION 297
EPDM HEAVY DUTY JACKET (ASTM D752) 299
FLEXIBLE CORD INSULATION 301
MEDIUM VOLTAGE (15 KV) INSULATION 303
NON-BLACK AUTOMOTIVE BUMPER STRIP 306
BRAKE CUP 307
MASTER CYLINDER RESERVOIR DIAPHRAGM 308
SOLID TIRE 309
BRAKE CUP 310
AUTOMOTIVE CLOSED CELL EXTRUDED SPONGE 311
DENSE AUTOMOTIVE EXTRUSION COMPOUND 312
70 SHORE A DENSE AUTOMOTIVE EXTRUSION COMPOUND 314
80 SHORE A DENSE AUTOMOTIVE EXTRUSION COMPOUND 315
EXTRUSION COMPOUNDS 317
EXTRUSION COMPOUNDS, MICROWAVE CURE 318
DENSE EXTRUSION COMPOUND FOR LCM CURE 319
GENERAL PURPOSE MOLDING COMPOUND 320
TRANSFER MOLDING COMPOUND 322
HIGH SPEED EXPANDER ROLL 323
90 DUROMETER NON-BLACK ROLL COMPOUND 324

BOAT DOCK BUMPER 325
40 DUROMETER NON-BLACK ROLL COMPOUND 326
50 SHORE A DENSE EXTRUSION COMPOUND........................ 327
PRESS MOLDED CLOSED CELL SHEET SPONGE..................... 328
EXTRUDED SPONGE COMPOUND FOR LCM CURING 329
SPONGE COMPOUND FOR INJECTION MOLDING................... 331
FLAME RESISTANT COMPOUND.. 333
MICROWAVE CURE FORMULA.. 334
WATER SPORTS EQUIPMENT 335
NON BLACK SPORTS EQUIPMENT 336
OUTDOOR MATTING... 337
GUN STOCK PAD 338
BUILDING PROFILES.. 339
C.V. CURED COMPACT PROFILES (UHF OR LCM CURING) 340
EXPANDED PROFILES (UHF OR “SHEAR HEAD” CURING) 341
48 SHORE A COMPOUND... 342
621 MPA (90,000 PSI) FLEXURAL MODULUS TPO 343
241 MPA (35,000 PSI) FLEXURAL MODULUS TPO 344
1034 MPA(150,000 PSI) FLEXURAL MODULUS TPO 345
NITRILE 347
FUEL HOSE.. 348
FUEL HOSE.. 350
FUEL HOSES 352
GASOLINE RESISTANT LINING.. 355
TRUCK FUELING HOSE TUBE.. 357
POLYBLEND FOR FUEL SERVICE.. 360
AUTOMOTIVE FUEL SERVICE 362
AUTOMOTIVE FUEL HOSE COVER.. 365
AUTOMOTIVE FUEL HOSE COVER.. 368
SOUR GASOLINE RESISTANT FUEL HOSE COMPOUND 371
MIL-H-6615B FUEL HOSE 373
MILITARY FUEL & OIL DISCHARGE HOSE TUBE.................. 374

INJECTION FUEL HOSES 376
FREON DIFFUSION & OIL/FUEL RESISTANT COMPOUND 378
POWER STEERING HOSE 379
AIR INTAKE HOSE 380
EMISSION CONTROL HOSE TUBE 382
AUTOMOTIVE AIR CONDITIONING HOSE 384
POWER STEERING SERVICE 385
AIR, OIL AND WATER SERVICE 388
GENERAL PURPOSE HYDRAULIC SERVICE 390
HIGH TEMPERATURE HYDRAULIC SERVICE 392
OIL SUCTION AND DISCHARGE SERVICE 394
HOSE FORMULAS 396
LIQUID PETROLEUM GAS SERVICE 398
LPG HOSE 400
LPG RESISTANT HOSE 401
FIRE HOSE COVER 402
HOSE FOR LOW TEMPERATURE RESISTANCE 404
HIGH PRESSURE HOSES 405
MILK HOSE 406
HOSE /BELT COVER FOR -40°C SERVICE 407
GASKET, BRAKE FLUID RESISTANCE 411
70 SHORE A OIL SEAL 412
INTANK ELECTRIC FUEL PUMP ISOLATOR FORMULATION 415
WATER PUMP SEAL COMPOUND FOR 138°C 416
LOW TEMPERATURE CAPABILITY FOR TRUCK HUB SEALS 418
SHOCK ABSORBER SEAL 420
OIL & LOW TEMPERATURE RESISTANT GASKET 422
GASKET, LOW TEMPERATURE AND GREASE RESISTANT 424
CORK GASKET 425
LOW TEMPERATURE GASKET 426
HEAT EXCHANGER GASKET 427
FILTER GASKET 428

GASKETS 430
GASKETS 431
TYPICAL 60 DUROMETER GASKET FORMULATION 434
SHAFT SEAL 436
SHAFT SEAL 437
PRESSURE COOKER SEAL 438
PRESSURE COOKER SEAL 439
TRANSFER MOLDED SEALS 441
O-RING 443
MOLDED GOODS COMPOUNDS 445
MOLDED GOOD FORMULATION 449
MOLDED GOODS FORMULATION 451
MOLDED GOODS FORMULATON 453
MOLDED GOODS COMPOUND 456
MOLDED GOODS COMPOUND 459
MOLDED GOODS COMPOUND 461
MOLDED GOODS COMPOUND 465
MOLDED GOODS COMPOUND 469
MOLDED GOODS FORMULATION 473
ASTM D-2000 SPECIFICATION – 3CH915A25B14E16E36 475
ASTM D-2000 SPECIFICATION – 2CH820A25B14E15E35F17 477
ROLLS 479
ROLL COMPOUNDS 480
DUROMETER 95 COMPOUND FOR ROLLS 481
DUROMETER 88 COMPOUND FOR ROLLS 482
70 SHORE A ROLL COMPOUNDS 483
NON-BLACK PRINTING ROLLS 484
NON-BLACK ROLLS 95 SHA 485
90 DUROMETER NON-BLACK ROLLS & GENERAL PURPOSE 486
90 DUROMETER NON-BLACK ROLLS & GENERAL PURPOSE 488
75 DUROMETER NON-BLACK FOR ROLL APPLICATIONS 490
NON-BLACK ROLLS 70 SHA 491

40 DUROMETER NON-BLACK ROLL FORMULATION 492
NON-BLACK ROLL COMPOUNDS 494
SOLES WITH HIGH SOLVENT RESISTANCE 495
ANTISTATIC SOLES 496
OIL RESISTANT SOLES 497
CHEMICAL RESISTANT SOLES 498
DUROMETER 68 COMPOUND FOR SOLING 500
DUROMETER 63 COMPOUND FOR SOLING 501
DIRECT MOLDED MICRO-CELLULAR SOLES 502
OIL WELL PACKERS 503
90 DURO DOWNHOLE PACKER COMPOUND 504
PACKERS 507
HIGH TEMPERATURE OIL WELL CABLE JACKET 509
OIL WELL CABLE JACKET COMPOUND 510
DRILL PIPE WIPER COMPOUND 514
DRILL PIPE PROTECTOR COMPOUND 518
ANNULAR BLOWOUT PREVENTER COMPOUND 521
BLACK CABLE SHEATH 60 SHA 525
BLACK CABLE SHEATH 70 SHA 527
BLACK CABLE SHEATH 80 SHA 529
NON-BLACK CABLE SHEATH 70 ShA 531
CONVEYOR BELT, HIGH ABRASION RESISTANCE 533
WHITE FOOD BELT COVERS 534
WHITE FOOD BELT COVERS 534
BLACK 90 DURO PEROXIDE CURED, LOW COMPRESSION SET 536
HIGH HARDNESS COMPOUND FOR COMPRESSION MOULD ... 538
85 SHORE A ULTRA LOW TEMPERATURE RESISTANT 539
80 DUROMETER WHITE RECIPES FOR ABRASION SERVICE ... 541
DUROMETER 77 COMPOUND FOR TEAR STRENGTH 543
DUROMETER 76 COMPOUND FOR ABRASION RESISTANCE 544
BLACK 65 DUROMETER, GENERAL PURPOSE ABRASION 545
LOW HARDNESS COMPOUNDS 546

DIESEL FUEL PUMP MEMBRANE 547
FUEL PUMP MEMBRANE 548
SHOCK ABSORBER SPECIFICATION...................................549
AIR SPRINGS FOR HIGHER TEMPERATURE APPLICATIONS ...550
CONDUCTIVE EXTRUSION COMPOUND................................553
FLOORING 554
LOW TEMPERATURE RESISTANT MEMBRANE 555
TRANSFORMER OIL RESISTANCE...556
MILK INFLATORS...557
MILK INFLATORS (BGA)...558
NON-BLACK MILKING MACHINE INFLATIONS 559
TORSIONAL VIBRATION DAMPER 560
INJECTION MOLDED COMPOUND...561
BLACK PEROXIDE CURED, ADHESION TO PRIMED METAL....562
DUROMETER 68 COMPOUND FOR BRASS ADHESION.............563
HIGH TEMPERATURE SERVICE...564
HIGH TEMPERATURE SERVICE...566
CLOSED CELL SPONGE INSULATION TUBING 568
CLOSED CELL SPONGE INSULATION TUBING 570
VINYL CLOSED CELL SHEET SPONGE 572
VINYL CLOSED CELL SPONGE – FLOTATION 574
LOW DENSITY CLOSED CELL INSULATION..........................576
COMPOUND TO MEET AMS 7272F...577
CHLORINATED, CHLOROSULFONATED PE ..579
FUEL HOSE..580
FUEL HOSE COVER...581
GENERAL PURPOSE HYDRAULIC HOSE COVER....................583
POWER STEERING HOSE TUBE AND COVER 584
POWER STEERING RETURN HOSE 585
GENERAL PURPOSE COVER..587
AUTO IGNITION WIRE...588
AIR INTAKE DUCT 589

ACID RESISTANT ROLL COMPOUND 591
POWER CABLE JACKET 592
HPN CORD 593
WHITE ROOFING COMPOUND 594
LOW DISCOLORATION TRANSLUCENT ARTICLE 595
DUROMETER 65 COMPOUND FOR BRASS ADHESION 596
DUROMETER 75, FABRIC ADHESION & BRASS ADHESION 597
URETHANE 599
25 DUROMETER NON-BLACK SULFUR CURE 600
30 DUROMETER BLACK SULFUR CURE 601
33 SHORE A NON-BLACK SULFUR CURED 602
37 SHORE A NON-BLACK SULFUR CURED 603
40 DUROMETER NON-BLACK SULFUR CURE 604
40 A HARDNESS RANGE 605
50 A HARDNESS RANGE - NON-BLACK 606
50 A HARDNESS RANGE - BLACK 607
50 DUROMETER NON-BLACK SULFUR CURE 608
50 DUROMETER BLACK SULFUR CURE 609
50 DUROMETER NON-BLACK PEROXIDE CURE 610
50 DUROMETER BLACK PEROXIDE CURE 611
60 DUROMETER NON-BLACK SULFUR CURE 612
60 DUROMETER BLACK SULFUR CURE 613
60 DUROMETER NON-BLACK PEROXIDE CURE 614
60 DUROMETER BLACK PEROXIDE CURE 615
BLACK 60 SHORE A 616
60 A HARDNESS RANGE - NON-BLACK 617
60 A HARDNESS RANGE - BLACK 618
70 A HARDNESS RANGE - NON-BLACK 619
70 A HARDNESS RANGE - BLACK 620
70 DUROMETER NON-BLACK SULFUR CURE 621
70 DUROMETER BLACK SULFUR CURE 622
70 DUROMETER NON-BLACK PEROXIDE CURE 623

70 DUROMETER BLACK PEROXIDE CURE 624
73 SHORE A BLACK SULFUR CURED 625
78 SHORE A BLACK PEROXIDE CURED 626
80 DUROMETER NON-BLACK SULFUR CURE 627
80 DUROMETER BLACK SULFUR CURE 628
80 DUROMETER NON-BLACK PEROXIDE CURE......................629
80 DUROMETER BLACK PEROXIDE CURE 630
80 A HARDNESS RANGE - BLACK 631
80 A HARDNESS RANGE - NON-BLACK 632
90 A HARDNESS RANGE - BLACK 633
90 A HARDNESS RANGE - NON-BLACK 634
90 DUROMETER NON-BLACK SULFUR CURE 635
90 DUROMETER BLACK SULFUR CURE 636
90 DUROMETER NON-BLACK PEROXIDE CURE......................637
90 DUROMETER BLACK PEROXIDE CURE 638
92 SHORE A BLACK COMPOUND, SULFUR CURE 639
92 SHORE A BLACK COMPOUND, PEROXIDE CURED 640
SILICONE, FLUOROELASTOMERS 641
FUEL HOSE 642
HOSE/EXTRUSION APPLICATIONS 643
HOSE/EXTRUSION APPLICATIONS 644
SILICONE SEAL COMPOUND 645
FLUOROSILICONE SEAL COMPOUND 646
AUTOMOTIVE FLUOROELASTOMER FUEL SEALS 647
NON-BLACK VALVE STEM SEALS 648
LOW TEMPERATURE FLUOROELASTOMER SERVICE SEALS .649
FLUOROELASTOMER SHAFT SEALS 650
FLUOROCARBON SEAL COMPOUNDS 651
O-RING GENERAL PURPOSE, INJECTION MOLDING 652
O-RING APLICATIONS 653
O-RING APLICATIONS 654
O-RING APLICATIONS 655

DUROMETER 50 COMPOUND FOR RESILIENCE, KEYPADS 656
MOLDED GOODS APPLICATIONS 657
MOLDED GOOD APPLICATIONS 658
MOLDED GOOD APPLICATIONS 659
FLUOROELASTOMER MOLDED GOODS 660
INJECTION MOLDABLE 661
CALENDERING COMPOUND 662
LOW HARDNESS FLUOROELASTOMER ARTICLES 663
NO POSTCURE FLUOROELASTOMER ARTICLES 664
LOW TEMPERATURE 665
FOOD GRADE APPLICATIONS 666
FABRIC COMPOSITE/CALENDERED SHEET APPLICATIONS 667
AGGRESSIVE OIL/COOLANT/BASE RESISTANT 668
AGGRESSIVE OIL/COOLANT/BASE RESISTANT 669
SILICONE SPONGE 670
ACRYLATE, EPICHLOROHYDRIN 671
ECO HIGH TEMPERATURE HOSE 672
HOSE FORMULAS 675
ACRYLATE SEAL COMPOUND 677
ACRYLATE SEAL COMPOUND 678
HIGH HEAT SERVICE WIRE INSULATION OR CABLE JACKET 679
FUEL HOSE 682
FUEL HOSE COVER 684
ECO SEAL COMPOUND 686
TRANSMISSION FLUID FILLER TUBE SEAL 687
FORMULAS FOR SMOOTH EXTRUSIONS 689
FORMULA FOR LOW TEMPERATURE FLEXIBILITY 690
FORMULA FOR LOW WATER SWELL 692
35 SHORE A COMPOUND 693
50 DUROMETER COMPOUND 694
60 DUROMETER COMPOUND 696
60 DURO COMPOUNDS 699

DUROMETER 70 COMPOUND FOR HEAT RESISTANCE 701
SPECIALTY RUBBERS 703
HEAT RESISTANT HOSE 704
HOSE LINER 705
INNERLINER COMPOSITION FOR SEVERE SERVICE 706
TIRE CURING BLADDER 707
NEW TIRE WHITE SIDEWALL COMPOSITION 708
HEAT RESISTANT ENGINE MOUNT 710
AUTOMOTIVE AIR DUCT 711
ROLL COMPOUND 712
FA ROLL COMPOUNDS 713
TYPICAL ST COMPOUND 714
COMPOUNDS FOR ASTM D-2000, TYPE A, CLASS K 715
LOW VOLTAGE CABLE INSULATION 716
HIGH AND LOW DAMPING COMPOUNDS 717
CELLULAR SHOE SOLING 718
DUROMETER 65 EVA COMPOUND, CASTOR WHEELS 719
DUROMETERS 80 & 85 EVA COMPOUNDS,TRANSPARENCY 720
DUROMETER 88 EVA COMPOUND FOR TEAR RESISTANCE 721
DUROMETER 92 EVA COMPOUND FOR FIRE RESISTANCE 722
APPENDIX 723
CHEMICAL ABBREVIATIONS 724
TRADE-NAMED RAW MATERIALS 728
SUPPLIERS' DIRECTORY 734
USEFUL FACTORS AND CONSTANTS 738
TENSILE STRENGTH CONVERSION TABLE 739
TEMPERATURE CONVERSION TABLE 740
CONVERSION OF MASSES AND MEASURES 741

RUBBER

INTRODUCTION

From Columbus onward, European explorers of Central and South America found the natives exploiting the elastic and water resistant properties of the dried latex from certain trees. The indigenous peoples already knew how to crudely waterproof fabrics and boots by coating them with latex and then drying. They also rolled dried latex into the bouncing balls used for sport. This dried latex became quite a curiosity in Europe, especially among the natural scientists. It received the name “rubber” in 1770 when John Priestly discovered that it could rub out pencil marks.

By the early nineteenth century, rubber was recognized as a flexible, tough, waterproof, and air-impermeable material. Commercial exploitation was stymied, however, by the fact that its toughness and elasticity made it difficult to process. More importantly, articles made from it became stiff and hard in cold weather, and soft and sticky in hot weather. The quest to make useful goods from rubber led Thomas Hancock of Great Britain to invent the rubber band and, in 1820, a machine to facilitate rubber processing. His “masticator” subjected the rubber to intensive shearing that softened it sufficiently to allow mixing and shaping. This development was followed, in 1839, by the discovery of vulcanization, which is generally credited to both Hancock and Charles Goodyear of the United States. Vulcanization – heating an intimate mixture of rubber and sulfur to crosslink the rubber polymer network – greatly improved rubber strength and elasticity and eliminated its deficiencies at temperature extremes. Upon this mechanical and chemical foundation, the rubber industry was born.

The source of rubber latex at that time was the *Hevea brasiliensis* tree, which is native to the Amazon valley. Brazil became the primary source of rubber, but as rubber use grew questions arose as to this country’s ability to insure adequate supply from its wild rubber trees. In 1876, Henry Wickham collected 70,000 Hevea seeds in Brazil and sent them to Kew Gardens in London for germination. Few seedlings resulted, but those that did allowed the British to establish a plantation system throughout the Far East.

Dunlop's patenting of the pneumatic tire in England in 1888 ushered in the age of the bicycle as a prelude to the era of automobiles. Tires need rubber, and the demand grew sufficiently great that in the early years of the twentieth century all sources of wild rubber in tropical America and Africa were being tapped. This demand, and the higher prices it caused, turned the plantations in Ceylon (Sri Lanka), Malaya (Malaysia), Singapore, and the East Indies (Indonesia) into prosperous enterprises. By 1914, plantation rubber had overtaken the production of wild rubber, and by 1920 it accounted for 90% of the world's supply.

The ready availability of high quality plantation rubber facilitated the advances in production methods and product quality which catalyzed the development of better automobiles and their reliance on rubber products. The demand for rubber also prompted research into the synthesis of practical substitutes. As early as the 1880s, organic chemists had identified isoprene as the main structural unit of rubber. By 1890, several researchers had made synthetic rubber-like polyisoprenes. With wild and plantation rubber readily available, however, synthetic alternatives remained mostly of academic interest. The Allied blockade of Germany during World War I changed this by demonstrating to Germany, and the world, the strategic importance of rubber in war. The Germans produced more than 2000 tons of methyl rubber by polymerizing 2,3-dimethyl-1,3-butadiene, but its properties were poor and its production was abandoned at the war's end.

The lesson was learned, nevertheless. The governments of Germany and Russia, the military nations most susceptible to loss of natural rubber through naval blockade, instituted programs to develop synthetic alternatives. This was given additional impetus in the mid-1920s by a forced rise in rubber prices due to British restrictions on plantation production. Work in Germany and Russia concentrated on polymers of 1,3-butadiene, since it was less expensive and easier to manufacture than isoprene (2-methyl-1,3-butadiene). This led to the production in the early 1930s of sodium catalyzed polybutadiene as SK rubber in Russia and Buna (from butadiene and Na) in Germany. These polymers were hard, tough, and difficult to process. Copolymerization of 1,3-butadiene with other monomers was pursued to obtain more easily processed and rubber-like products. In Germany this led within a few years to Buna S, a copolymer of butadiene and styrene, and Buna N, a copolymer of butadiene and acrylonitrile.

By the time war broke out in 1939, both Germany and Russia could satisfy their rubber needs with reasonably satisfactory synthetic products. As the war spread to the Far East, the U.S. government realized its supply of natural rubber was at risk. In 1940 it established the Rubber Reserve Company as a government corporation. This organization was charged with stockpiling natural rubber and instituting a synthetic rubber research and development program. Based on the technology developed in Germany and Russia prior to the war, styrene-butadiene polymers became the focus of development efforts as the best general-purpose alternative to natural rubber.

The Japanese also identified the strategic significance of natural rubber to both the United States and Great Britain. Following Pearl Harbor, the Japanese promptly cut off most of the Far East supply. It was only the rapid development of synthetic rubber production in the U.S. that negated this. Production of styrene-butadiene rubber (SBR), then called GR-S, began in a government plant in 1942. Over the next three years, government financed construction of 15 SBR plants brought annual production to more than 700,000 tons.

Although SBR was the workhorse substitute for natural rubber during the war years, it was supplemented by neoprene, butyl rubber, and nitrile rubber. Neoprene, poly(2-chloro-1,3-butadiene) had been introduced by DuPont in 1931 as DuPrene and was actually the first commercially successful synthetic elastomer. Neoprene provided high tensile strength like natural rubber and significantly better weather and oil resistance, but it was too expensive for consideration as a general purpose elastomer. Its production rose from 9,000 tons to 45,000 tons between 1942 and 1945. Butyl rubber had been invented at Standard Oil when it was discovered that the saturated chemical structure of rubber-like high molecular weight isobutylene polymers could be vulcanized by incorporating a small amount of isoprene into the polymer. The resulting elastomer showed unique and useful properties, particularly low gas permeability. Construction of the first butyl rubber plant had already begun in 1941, but the facility was nationalized and put into full production by 1943. Most of the wartime output went into inner tubes for military and essential civilian vehicles. From a base of 1400 tons in 1943, butyl rubber production rose rapidly to over 47,000 tons in 1945. Nitrile rubber, the current common name for acrylonitrile-butadiene rubber, showed such great potential as a special-purpose oil- and solvent-resistant rubber that its commercialization in Germany was followed by production at four new U.S. plants by the time of America’s entry into the war. The expanding industrial market for this elastomer was immediately pre-empted by strict allocation for military use. By the end of the war, production had risen to 15,000 tons per year.

World War II represents the accelerated adolescence of the rubber industry, the preparation for its great postwar maturation and growth. Developments in organic and polymer chemistry provided insight into the properties of natural rubber, which led to neoprene, SBR, nitrile and butyl rubber. These were made practically and commercially significant, however, only by the complementary developments in compounding. Amine vulcanization accelerators were discovered at Diamond Rubber in 1906. The value of carbon black to the improvement of rubber physical properties was discovered at Diamond Rubber in 1912. Internal mixers for compounding were first offered by Fernley Banbury in 1916. Guanidines and thiazoles began use as accelerators in 1921. By the end of the Second World War, compounding art and science had fully bridged the gap between elastomer and rubber product.

COMPOUNDING MATERIALS

Today there is a wide variety of rubber polymers, each with its own set of characteristic attributes, and each offered with modifications designed to enhance one or more of those attributes. In most cases, nevertheless, the elastomer by itself lacks one or more property necessary to produce a sale-able product. A number of materials must be added to make it commercially useful. Compounding is the means by which elastomer and additives are combined to ensure efficient manufacture of the best possible product. The design of a compound formula is the basic function of rubber technology.

The compounding of rubber products starts with the choice of elastomer, filler (reinforcing or extending), crosslinking chemicals, and various additives which, when mixed together, will provide a compound with the desired properties and performance. Mixing is followed by forming operations such as milling, extrusion, and calendering. These lead to the final processing step of vulcanization or curing in which the compound changes from a thermoplastic to a thermoset or crosslinked state.

ELASTOMERS

The first step in effective compounding is the selection of the proper elastomer. The inherent properties of each elastomer determine its suitability for any given application. These properties are a function of elastomer chemistry, which in turn is determined by manipulation of synthesis variables. The synthesis of the natural rubber polymer is, of course, dictated by nature and genetics, although adjustments to the process of converting the latex to solid rubber enables some latitude in modifying properties.

Most synthetic elastomers are made by either solution or emulsion polymerization. In some cases, both methods are used to provide respectively characteristic grades of the given polymer. In general, emulsion polymerization provides broader molecular weight distribution and better milling qualities. Solution polymerization generally results in narrower molecular weight distribution, poorer milling qualities, but better physical properties in the cured state. Figures 1a and 1b gives the most commonly used elastomers along with their industry accepted abbreviation and structural formula.

Natural Rubber (NR)

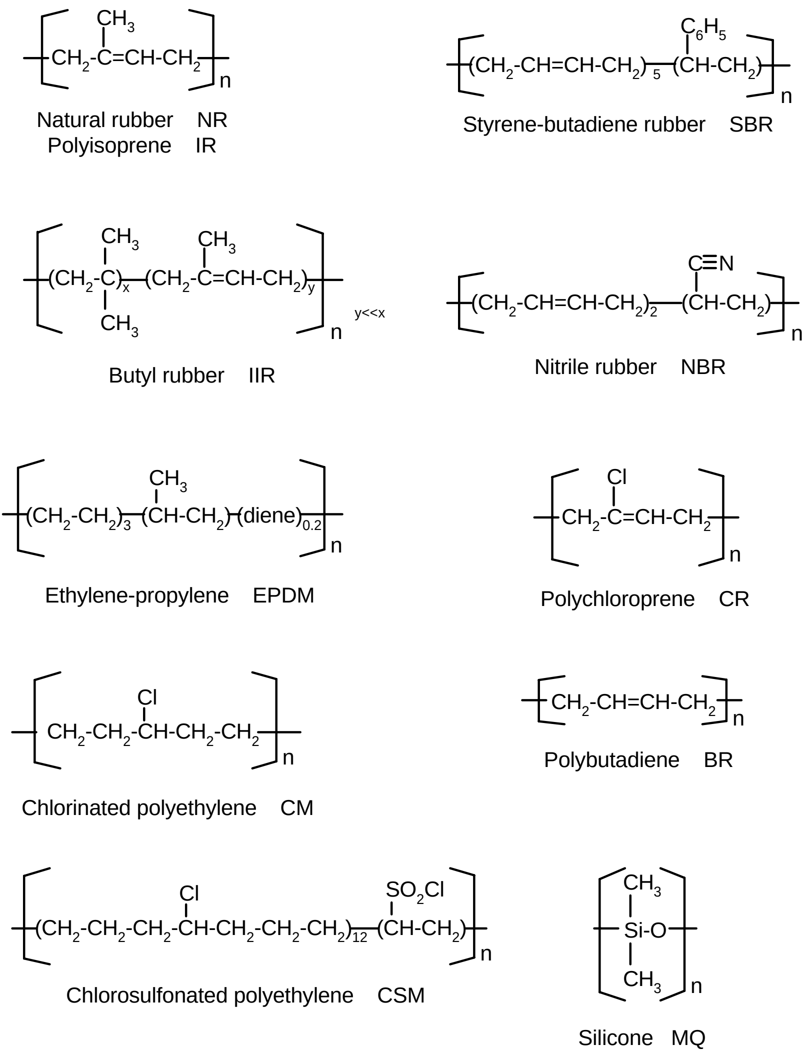
Natural rubber is the prototype of all elastomers. It is extracted in the form of latex from the bark of the Hevea tree. The rubber is collected from the latex in a series of steps involving preservation, concentration, coagulation, dewatering, drying, cleaning, and blending. Because of its natural derivation, it is sold in a variety of grades based on purity (color and presence of extraneous matter), viscosity, viscosity stability, oxidation resistance, and rate of cure. Modified natural rubbers are also available, with treatment usually performed at the latex stage. These include epoxidized natural rubber (ENR); deproteinized natural rubber (DNR); oil extended natural rubber (OENR), into which 10-40% of process oils have been incorporated; Heveaplus MG rubber – natural rubber with grafted poly(methyl methacrylate) side chains; and thermoplastic natural rubber (TNR) – blends of natural rubber and polypropylene.

The natural rubber polymer is nearly 100% *cis*-1,4 polyisoprene with M_w ranging from 1 to 2.5 x 10^6. Due to its high structural regularity, natural rubber tends to crystallize spontaneously at low temperatures or when it is stretched. Low temperature crystallization causes stiffening, but is easily reversed by warming. The strain-induced crystallization gives natural rubber high tensile strength and resistance to cutting, tearing, and abrasion.

Like other high polymers, natural rubber can be pictured as a tangle of randomly oriented sinuous polymer chains. The “length” of these chains is a function of their thermodynamic behavior and is determined as the statistically most probable distance between each end. This chain length reflects the preferred configuration of the individual polymer molecule. The application of force to a rubber sample effectively changes the chain length. When the force is removed, the chain tries to regain its preferred configuration. In simple terms, this can be compared to the compression or extension of a spring. This effect is the basis of rubber’s elasticity.

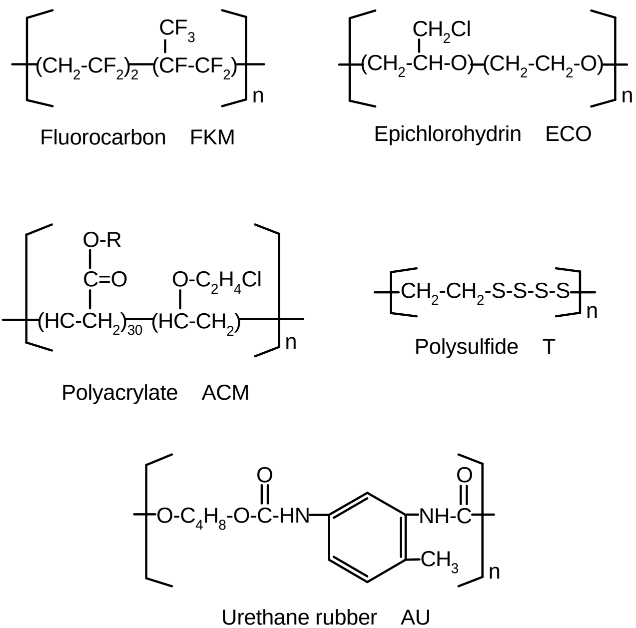
Elasticity is one of the fundamentally important properties of natural rubber. Rubber is unique in the extent to which it can be distorted, and the rapidity and degree to which it recovers to its original shape and dimensions. It is, however, not perfectly elastic. The rapid recovery is not complete. Part of the distortion is recovered more slowly and part is retained. The extent of this permanent distortion, called permanent set, depends upon the rate and duration of the applied force. The slower the force, and the longer it is maintained, the greater is the permanent set. Because of rubber’s elasticity, however, the permanent set may not be complete even after long periods of applied force. This quality is of obvious value in gaskets and seals.

Figure 1a. Common Elastomers



The rubber's polymer network allows elasticity and flexibility to be combined with crystallization-induced strength and toughness when stretched. The elastic nature of this network also accounts for the exceptional resilience of cured rubber products. This resilience means less kinetic energy is lost as heat during repeated stress deformation. Products made from natural rubber are less likely than most other elastomers to fail from excessive heat buildup or fatigue when exposed to severe dynamic conditions. This has secured the place of natural rubber as the preferred sidewall elastomer in radial tires.

Figure 1b. Common Specialty Elastomers



As already noted, the rubber polymer network was originally an impediment to rubber processing. Mixing additives with a tough, elastic piece of raw rubber was a substantial challenge. The solution came with the discovery of its thermoplastic behavior. High shear and heat turn the rubber soft and plastic through a combination of extension, disentanglement, and oxidative cleavage of polymer chains. In this state it is considerably more receptive to the incorporation of additives so that the rubber's natural attributes can be modified and optimized as desired. The commercial utility of natural rubber has in fact grown from the ease with which its useful properties can be changed or improved by compounding techniques.

Another important and almost unique quality of uncured natural rubber compounds is building tack. When two fresh surfaces of milled rubber are pressed together they bond into a single piece. This facilitates the building of composite articles from separate components. In tire manufacture, for example, the separate pieces of uncured tire are held together solely by building tack. During cure they fuse into a single unit.

Following World War II, natural rubber's virtual 100% market share dropped under the competitive pressure of synthetic elastomers. It nevertheless still accounts for about 1/3 of all elastomers used because of its unique balance of properties. This level of demand is supported mainly by tires and tire products, which account for over 70% of natural rubber consumption. Natural rubber is used in the carcass of passenger car cross-ply tires for its building tack, ply adhesion, and good tear resistance. It is also used in the sidewalls of radial ply tires for its fatigue resistance and low heat buildup. In tires for commercial and industrial vehicles, natural rubber content increases with tire size. Almost 100% natural rubber is used in the large truck and earthmover tires which require low heat buildup and maximum cut resistance. Natural rubber is also used in industrial goods, such as hoses, conveyor belts, and rubberized fabrics; engineering products, for resilient load bearing and shock or vibration absorption components; and latex products such as gloves, condoms, and adhesives.

Styrene-Butadiene Rubber (SBR)

SBR polymers are widely produced by both emulsion and solution polymerization. Emulsion polymerization is carried out either hot, at about 50^{o}C, or cold, at about 5^{o}C, depending upon the initiating system. SBR made in emulsion usually contains about 23% styrene randomly dispersed with butadiene in the polymer chains. SBR made in solution contains about the same amount of styrene, but both random and block copolymers can be made. Block styrene is thermoplastic and at processing temperatures helps to soften and smooth out the elastomer. Both cold emulsion SBR and solution SBR are offered in oil-extended versions. These have up to 50% petroleum base oil on polymer weight incorporated within the polymer network. Oil extension of SBR improves processing characteristics, primarily allowing easier mixing, without sacrificing physical properties.

SBR was originally produced by the hot emulsion method, and was characterized as more difficult to mill, mix, or calender than natural rubber, as well as being deficient in building tack, and having relatively poor inherent physical properties. Processability and physical properties were found to be greatly improved by the addition of process oil and reinforcing agents. "Cold" SBR generally has a higher average molecular weight and narrower molecular weight distribution. It thereby offers better abrasion and wear resistance plus greater tensile and modulus than “hot” SBR. Since higher molecular weight can make cold SBR more difficult to process, it is commonly offered in oil-extended form. Solution SBRs can be tailored in polymer structure and properties to a much greater degree than their emulsion counterparts. The random copolymers offer narrower molecular weight distribution, low chain branching, and lighter color than emulsion SBR. They are comparable in tensile, modulus, and elongation, but offer lower heat buildup, better flex, and higher resilience. Certain grades of solution SBR even address the polymer's characteristic lack of building tack, although it is still inferior to that of natural rubber.

The processing of SBR compounds in general is similar to that of natural rubber in the procedures and additives used. SBR is typically compounded with better abrasion, crack initiation, and heat resistance than natural rubber. SBR extrusions are smoother and maintain their shape better than those of natural rubber.

SBR was originally developed as a general purpose elastomer and it still retains this distinction. It is the largest volume and most widely used elastomer worldwide. Its single largest application is in passenger car tires, particularly in tread compounds for superior traction and treadwear. Substantial quantities are also used in footwear, foamed products, wire and cable jacketing, belting, hoses, and mechanical goods.

Polybutadiene Rubber (BR)

This elastomer was originally made by emulsion polymerization, generally with poor results. It was difficult to process and did not extrude well. Polybutadiene became commercially successful only after it was made by solution polymerization using stereospecific Ziegler-Natta catalysts. This provided a polymer with greater than 90% *cis*-1,4-polybutadiene configuration. This structure hardens at much lower temperatures (with T_g of -100^{o}C) than natural rubber and most other commercial elastomers. This gives better low temperature flexibility and higher resilience at ambient temperatures than most elastomers. Greater resilience means less heat buildup as well under continuous dynamic deformation. This high-*cis* BR was also found to possess superior abrasion resistance and a great tolerance for high levels of extender oil and carbon black. High-*cis* BR was originally blended with natural rubber simply to improve the latter’s processing properties, but it was found that the BR conferred many of its desirable properties to the blend. The same was found to be true in blends with SBR.

The 1,3-butadiene monomer can polymerize in three isomeric forms: by *cis* 1,4 addition, *trans* 1,4 addition, and 1,2 addition leaving a pendant vinyl group. By selection of catalyst and control of processing conditions, polybutadienes are now sold with various distributions of each isomer within the polymer chain, and with varying levels of chain linearity, molecular weight and molecular weight distribution. Each combination of chemical properties is designed to enhance one or more of BR's primary attributes.

The largest volume use of polybutadiene is in passenger car tires, primarily in blends with SBR or natural rubber to improve hysteresis (resistance to heat buildup), abrasion resistance, and cut growth resistance of tire treads. The type of BR used depends on which properties are most important to the particular compound. High-*cis* and medium-*cis* BR have excellent abrasion resistance, low rolling resistance, but poor wet traction. High-vinyl BRs offer good wet traction and low rolling resistance, but poor abrasion resistance. Medium-vinyl BRs balance reasonable wet traction with good abrasion resistance and low rolling resistance. Polybutadiene is also used for improved durability and abrasion and flex crack resistance in tire chaffer, sidewalls and carcasses, as well as in elastomer blends for belting. High- and medium-*cis* BRs are also used in the manufacture of high impact polystyrene. Three to twelve percent BR is grafted onto the styrene chain as it polymerizes, confering high impact strength to the resultant polymer.

Butyl Rubber (IIR)

Butyl rubber is the common name for the copolymer of isobutylene and 1 to 3% isoprene produced by cold (-100^{o}C) cationic solution polymerization. Isoprene provides the unsaturation required for vulcanization. Most of butyl rubber's distinguishing characteristics are a result of its low level of chemical unsaturation. The essentially saturated hydrocarbon backbone of the IIR polymer will effectively repel water and polar liquids but show an affinity for aliphatic and some cyclic hydrocarbons. Products of butyl rubber will therefore be swollen by hydrocarbon solvents and oils, but show resistance to moisture, mineral acids, polar oxygenated solvents, synthetic hydraulic fluids, vegetable oils, and ester-type plasticizers. It is likewise highly resistant to the diffusion or solution of gas molecules. Air impermeability is the primary property of commercial utility. The low level of chemical unsaturation also imparts high resistance to ozone. Sulfur-cured butyl rubber has relatively poor thermal stability, softening with prolonged exposure at temperatures above 150^{o}C because the low unsaturation prevents oxidative crosslinking. Curing with phenol-formaldehyde resins instead of sulfur, however, provides products with very high heat resistance, the property responsible for a large market in tire-curing bladders.

The molecular structure of the polyisobutylene chain provides less flexibility and greater delayed elastic response to deformation than most elastomers. This imparts vibration damping and shock-absorption properties to butyl rubber products.

The unique properties of butyl rubber are used to advantage in tire inner tubes and air cushions (air impermeability), sheet roofing and cable insulation (ozone and weather resistance), tire-curing bladders, hoses for high temperature service, and conveyor belts for hot materials (thermal stability with resin cure).

Halobutyl Rubber (CIIR, BIIR)

Halobutyl rubbers are produced by the controlled chlorination (chlorobutyl; CIIR) or bromination (bromobutyl; BIIR) of butyl rubber. Halogenation produces an allylic chlorine or bromine adjacent to the double bond of the isoprene unit. The halogenated butyl rubbers share many of the attributes of their butyl rubber parent: superior air impermeability, resistance to chemicals, moisture, and ozone, and vibration damping. The presence of halogen provides new crosslinking chemistry and the ability for adhesion to and vulcanization with general purpose, highly unsaturated elastomers. Bromobutyl is generally faster curing than chlorobutyl and somewhat more versatile in the curing systems that can be used to tailor product properties. Halobutyl rubbers typically use a zinc oxide-based cure, but bromobutyl can be vulcanized with peroxide or magnesium oxide as well.

The primary application for halobutyl rubber is in tires. The combination of low gas and moisture permeability, high heat and flex resistance, and ability to covulcanize with highly unsaturated rubber has secured the use of these rubbers in the innerliners of tubeless tires. Passenger tires use chlorobutyl alone or in a blend with 20 to 40% natural rubber. High-service steel-belted truck tires use 100% bromobutyl innerliner compounds. Chlorobutyl is also used for truck inner tubes for its superior heat resistance compared to butyl rubber. Halobutyl rubbers are added to sidewall compounds for improved ozone and flex resistance, and to certain tread compounds for improved traction and wet skid resistance.

Halobutyl rubbers are also used in vibration damping mounts and pads, steam and automatic dishwasher hoses, chemical-resistant tank linings, and heat-resistant conveyor belts. They are also widely used in pharmaceutical closures because of their low gas and moisture permeability, resistance to aging and weathering, chemical and biological inertness, low extractables (with metal oxide cures), and good self-sealing and low fragmentation during needle penetration.

Neoprene (CR)

Neoprene is the common name for the polymers of chloroprene (2-chloro-1,3-butadiene). These are produced by emulsion polymerization. The chloroprene monomer can polymerize in four isomeric forms: *trans* 1,4 addition; *cis* 1,4 addition; 1,2 addition, leaving a pendant vinyl group and allylic chlorine; and 3,4 addition. Neoprene is typically 88-92% *trans*, with degree of polymer crystallinity proportional to *trans* content. *Cis* addition accounts for 7-12% of the structure and 3,4 addition makes up about 1%. The approximately 1.5% of 1,2 addition is believed to provide the principal sites of vulcanization.

The high structural regularity (high *trans* content) of neoprene allows the strain-induced crystallization that results, as for natural rubber, in high tensile strength. The 2-chloro substituent, instead of natural rubber's 2-methyl, results in a higher freezing point (poorer low temperature resistance) and alters vulcanization requirements. Neoprenes are generally cured with zinc oxide and magnesium oxide, or lead oxide for enhanced water resistance. The presence of chlorine in the polymer structure improves resistance to oil, weathering, ozone and heat. The improved oxidation resistance is due to the reduced activity of the double bonds caused by the chlorine. Except for low temperature resistance and price, neoprene would be considered nearly as versatile as natural rubber.

There are three types of general purpose neoprenes – G, W, and T types – with selected features modified to offer a range of processing, curing and performace properties. Products are made from neoprene because it offers good building tack, good oil, abrasion, chemical, heat, weather, and flex resistance, and physical toughness. Neoprene is widely used in hoses of all types (water, oil, air, automotive, industrial), wire and cable jacketing, power transmission and conveyor belting, bridge and building bearings, pipe gaskets, footwear, roof coatings, and coated fabrics.

Nitrile Rubber (NBR)

Nitrile rubber is the generic name given to emulsion polymerized copolymers of acrylonitrile and butadiene. Its single most important property is exceptional resistance to attack by most oils and solvents. It also offers better gas impermeability, abrasion resistance, and thermal stability than the general purpose elastomers like natural rubber and SBR. These attributes arise from the highly polar character of acrylonitrile, the content of which determines the polymer's particular balance of properties. Commercial nitrile rubbers are available with acrylonitrile/butadiene ratios ranging from 18:82 to 45:55. As acrylonitrile content increases, oil resistance, solvent resistance, tensile strength, hardness, abrasion resistance, heat resistance, and gas impermeability improve, but compression set resistance, resilience and low temperature flex deteriorate. Selection of the particular grade of NBR needed is generally based on oil resistance vs. low temperature performance. Blends of different grades are common to achieve the desired balance of properties.

Nitrile elastomers do not crystallize when stretched and so require reinforcing fillers to develop optimum tensile strength, abrasion resistance, and tear resistance. They also possess poor building tack. Although nitrile rubbers are broadly oil- and solvent-resistant, they are susceptible to attack by certain strongly polar liquids, to which the nonpolar rubbers, such as SBR or natural rubber, are resistant. Nitrile rubber is poorly compatible with natural rubber, but can be blended in all proportions with SBR. This decreases overall oil resistance, but increases resistance to polar liquids in proportion to the SBR content. Nitrile polymers are increasingly used as additives to plastics to provide elastomeric properties. Blends with polyvinyl chloride are popular for confering improved abrasion, tensile, tear, and flex properties.

Nitrile rubber is used primarily in soling, plus hoses, tubing, linings, and seals used for the conveyance or retention of oils and solvents.

Ethylene Propylene Rubbers (EPM, EPDM)

The first commercial ethylene propylene rubbers were made by the random copolymerization of ethylene and propylene in solution using Ziegler-Natta catalysts. Since these compounds (EPM) were fully saturated, they were highly resistant to oxidation, ozone, heat, weathering, and polar liquids. They could be cured, however, only by peroxide. The greater versatility of a sulfur curable elastomer was sought, and found by the incorporation of limited amounts of a third monomer into the polymer. Dienes were found which were compatible with the EPM polymerization process, and which had one double bond that would preferentially polymerize to leave a pendant double bond available for vulcanization. The latter criteria left the polymer backbone saturated and capable of offering the same high level of stability as EPM. The dienes most commonly used today to make the ethylene propylene diene polymers (EPDM) are 1,4 hexadiene, ethylidene, norbornene and dicyclopentadiene, each conferring a different rate and state of cure to the polymer.

An extensive range of EPDM polymers are produced by varying the molecular weight, molecular weight distribution, ethylene/propylene ratio and level and type of diene termonomer. Elastomers are available containing from 50% to more than 75% ethylene by weight. Polymers with lower ethylene content are amorphous and easy to process. Higher ethylene content gives crystalline polymers with better physical properties, but more difficulty in processing. The amount of terpolymer is typically 1.5 to 4%, but can be as high as 11% in ultra-fast curing grades. Most EPDMs are incompatible with diene rubbers (eg. natural, SBR, NBR) because of their relatively slow cure rate. The ultra-fast cure EPDMs overcome this.

In general, the ethylene propylene rubbers are compounded to provide good low-temperature flexibility, high tensile strength, high tear and abrasion resistance, excellent weatherability (ozone, water, oxidation resistance), good electrical properties, high compression set resistance, and high heat resistance. The high molecular weight crystalline EPDMs can incorporate high levels of fillers. EPMs and EPDMs have low resistance to hydrocarbon oils and their lack of building tack must be compensated for by the use of resin.

The ethylene propylene rubbers are probably the most versatile of the general purpose elastomers, and can be compounded in nearly the full spectrum of applications not requiring resistance to hydrocarbon oils. The high volume use is in tire sidewalls as an additive to improve ozone resistance. Other major uses which exploit their desirable properties and versatility are single-ply roofing and ditch liners, automotive seals, gaskets, weatherstripping and boots, appliance parts, and hosing. Outside the rubber industry, they are used as viscosity modifiers in lubricating oils; they improve low temperature impact strength when added to polyolefins at low levels; and they form thermoplastic elastomers when blended in higher ratios with polyolefins or other thermoplastic resins.

Polyisoprene (IR)

Polyisoprene is made by solution polymerization of isoprene (2-methyl-1,3-butadiene). The isoprene monomer, the structural unit of the natural rubber polymer, can polymerize in four isomeric forms: *trans* 1,4 addition, *cis* 1,4 addition, 1,2 addition, leaving a pendant vinyl group, and 3,4 addition. The production of a synthetic analogue to natural rubber was stymied for over 100 years because polymerization of isoprene resulted in mixtures of isomeric forms. In the 1950s, rubber-like elastomers with >90% *cis* 1,4 isoprene configuration were finally produced using stereospecific catalyts.

Polyisoprene compounds, like those of natural rubber, exhibit good building tack, high tensile strength, good hysteresis, and good hot tensile and hot tear strength. The characteristics which differentiate polyisoprene from natural rubber arise from the former's closely controlled synthesis. Polyisoprene is chemically purer – it does not contain the proteins and fatty acids of its natural counterpart. Molecular weight is lower than natural rubber's, and lot-to-lot uniformity is better. Polyisoprene is therefore easier to process, gives a less variable (although generally slower) cure, is more compatible in blends with EPDM and solution SBR, and provides less green strength (pre-cure) than natural rubber. Polyisoprene is added to SBR compounds to improve tear strength, tensile strength, and resilience while decreasing heat buildup. Blends of polyisoprene and fast curing EPDM combine high ozone resistance with the good tack and cured adhesion uncharacteristic of EPDM alone.

Polyisoprene is typically used in favor of natural rubber in applications requiring consistent cure rates, tight process control, or improved extrusion, molding, and calendering. Tires are the leading consumer. The synthetic elastomer can be produced with the very low level of branching, high molecular weight, and relatively narrower molecular weight distribution that contributes to lower heat buildup compared to natural rubber. For this reason, certain grades of polyisoprene are used as a alternative to natural rubber in the tread of high service tires (truck, aircraft, off-road) without sacrificing abrasion resistance, groove cracking, rib tearing, cold flex properties, or weathering resistance. Footwear and mechanical goods are also major uses. Because of polyisoprene's high purity and the high gum (unfilled) tensile strength of its compounds, it is widely used in medical goods and food-contact items. These include baby bottle nipples, milk tubing, and hospital sheeting.

Chlorinated and Chlorosulfonated Polyethylene (CM, CSM)

Chlorinated polyethylene (CM) is produced by the chlorination of high density polyethylene either in solvent solution or aqueous suspension. The substituent chlorine on the saturated olefin backbone enhances heat and oil resistance. The chlorine also provides flame resistance. The polymer is thermoplastic when processed on conventional elastomer equipment, and compounds can be molded, calendered or extruded. Chlorinated polyethylene is most often steam cured using a peroxide curing system. The major end use is wire and cable applications, particularly flexible cords for up to 600 volts. Other major uses are in automotive hose, sheet goods and as an impact modifier in plastics.

Simultaneous chlorination and chlorosulfonation of high density polyethylene in an inert solvent yields chlorosulfonated polyethylene (CSM). Grades are available with chlorine contents ranging from 24 to 43% and sulfur from 1.0 to 1.4%. CSM is widely used in the rubber industry because its compounds are odorless, light stable, and easily colored, highly resistant to oxygen, ozone, weathering, and corrosive chemicals, and resistant to abrasion, heat, low temperatures, oil, and grease. They also have excellent electrical properties and provide high tensile properties without highly reinforcing fillers. The particular degree and balance of these attributes is governed primarily by chlorine content. Increasing chlorine gives increasing flame and oil resistance, decreasing heat and electrical resistance and low temperature flexibility, and slightly decreasing ozone resistance.

Uncured chlorosulfonated polyethylene is more thermoplastic than other commonly used elastomers. It is generally tougher at room temperature, but softens more rapidly on heating. Vulcanization can be obtained with peroxides, as with other chemically saturated polymers, or with sulfur crosslinking at the sulfonyl chloride groups. The former promotes better resistance to heat and compression set, the latter can result in high tensile strength and excellent mechanical toughness. Compounds can also be cured at ambient temperatures by the combination of water (atmospheric moisture) and a divalent metal oxide (magnesia), which form sulfonate salt bridges. These ionic cures are slow but develop high modulus.

Ambient temperature ionic curing of CSM has led to its major use in single-ply roofing membranes and geomembranes for reservoir liners and waste dump liners. Roofing membranes are installed in an uncured thermoplastic state, with seaming by heat or solvents. Weathering slowly cures the membrane, progressively increasing durability and toughness. Because these compounds are easily colored, they can be made with heat reflective or absorptive colors as required. An alternative approach is to coat a neoprene or EPDM membrane with CM paint.

The combination of colorability, toughness, enviromental durability and resistance to flame, oil, radiation and corrosive chemicals has also secured CSM’s widespread use in automotive hoses, tubes, gasketing and wiring, electrical wire insulation for up to 600 volts, wire insulation in nuclear power stations, industrial hoses and tank linings, coated fabrics, hot conveyor belting, and construction coatings and gaskets.

Silicone Rubber

Because of its unique properties and somewhat higher price compared to the other common elastomers, silicone rubber is usually classed as a specialty elastomer, although it is increasingly used as a cost-effective alternative in a variety of applications. Two types of silicone elastomers are available, each providing the same fundamental properties. These are the thermosetting rubbers that are vulcanized with heat, and RTV (room temperature vulcanizing) rubbers.

The basic silicone polymer is dimethylpolysiloxane with a backbone of silicon-oxygen linkages and two methyl groups on each silicon. The silicon-oxygen backbone provides a high degree of inertness to ozone, oxygen, heat (up to 315°C), UV light, moisture, and general weathering effects, while the methyl substituents confer a high degree of flexibility. The basic polymer properties are modified by replacing minor amounts of the methyl substituents with phenyls and/or vinyls. Phenyl groups improve low temperature flexibility (to as low as -100°C) without sacrificing high temperature properties. Vinyl groups improve compression set resistance and facilitate vulcanization. Of the available silicone elastomers – methyl silicone (MQ), methyl-vinyl silicone (VMQ), methyl-phenylsilicone (PMQ), methyl-phenyl-vinyl silicone (PVMQ), and fluoro-vinyl-methyl silicone (FVMQ) – the methyl-vinyl types are most widely used.

Thermal vulcanization typically uses peroxides to crosslink at the vinyl groups of the high molecular weight solid silicone rubbers. Compounded products offer the attributes noted above plus superior resistance to compression set, excellent biocompatability, vibration damping over a wide temperature range, and thermal ablative properties. The latter enables the silicone rubber to form a thermally insulating surface char on exposure to temperatures up to 5,000°C. The rubber remains elastomeric beneath the char. Silicone elastomers generally offer poorer tensile, tear, and abrasion properties than the more common organic rubbers, but this is routinely improved by reinforcement with fumed silica, which also improves electrical insulation properties.

Room temperature vulcanizing (RTV) silicones are low molecular weight dimethylpolysiloxane liquids with reactive end groups. As with the heat cured polymers, there can be minor substitution of methyl groups with phenyls – for improved low temperature flexibility – or with fluoroalkyl groups – for improved oil and solvent resistance and even broader temperature service. Vulcanization of the RTV silicones is obtained from either a condensation or an addition reaction. Condensation cures can be either moisture independent or moisture dependent. For moisture independent compounds, the reactive polymer end group is usually silanol. The crosslinking agent may be a silicone with silanol end groups, using an organic base as the condensation catalyst, an alkoxysilicate (e.g., ethyl silicate), using a metallic salt catalyst, or a polyfunctional aminoxy silicone, often requiring no catalyst. These compounds are known as “two-package” RTVs since the curing agent and/or catalyst is kept separate and added to the compound just prior to use.

Moisture-curing compounds, also known as “one-package” RTVs, are compounded from silanol-terminated polymer with a polyfunctional silane curing agent (e.g., methyltriacetoxysilane) and condensation catalyst, or from a polymer end-stopped with the curing agent. Crosslinking occurs on exposure to atmospheric moisture, starting at the surface and progressing inward with diffusion of moisture into the compound.

Addition-cured RTVs are typically compounded from a dimethylvinylsiloxy-terminated polymer, a polyfunctional silicon hydride crosslinker, and a metal ion catalyst. Vulcanization is independent of moisture and air and forms no volatile byproducts. These products are usually sold as two-package RTVs, but are also available as one-package compounds containing an inhibitor which is volatilized or deactivated by heat to trigger the cure.

Most fabricators of silicone rubber products do not do their own compounding, but purchase premixed compounds requiring only catalyst and/or curing. Solid (thermally cured) rubbers are used in automotive underhood applications, primarily for their heat resistance. Products include ignition cables, coolant and heater hoses, O-rings, and seals. Similar applications are found in aircraft seals, connectors, cushions, and hoses, and in home appliance O-rings, seals, and gaskets. Long service life plus circuit integrity (from ablative charing) with no toxic gas generation have secured the place of silicone rubber in wire and cable insulation for electric power generation and transmission, for naval shipboard cable of all types, and for appliance wiring. The inherent inertness and biocompatibility of silicone rubbers have enabled their use in food contact and medical products. These include baby bottle nipples, belts and hoses for conveying foods and food ingredients, surgical tubing, subdermal implants, and prosthetic devices.

RTV silicones are used by the automotive, appliance, and aerospace industries for electronic potting compounds and formed-in-place gaskets, to form molds for the manufacture of plastic parts, and widely in construction adhesives, sealants, roof coatings, and glazing.

Special Purpose Elastomers

The special purpose rubbers are typically premium priced but cost effective in supplying one or more unique property for demanding applications.

Fluoroelastomers – These are chemically saturated co- and terpolymers of vinylidene fluoride, hexafluoropropylene, tetrafluoroethylene, perfluoro (methyl vinyl) ether, and propylene in various combinations. They are designed to provide extraordinary levels of resistance to oil, chemicals, and heat. They are generally classified into four groups: A, B, F, and Specialty. The lettered groups have increasing fluid resistance, reflecting their increasing flourine levels of 66%, 68%, and 70% respectively. The Specialty group contains further enhanced properties, such as improved low temperature flexibility. Some fluoroelastomers incorporate a bromine-containing curesite monomer and can be vulcanized with peroxides. The rest are most often cured with bisphenol. Because of their exceptional resistance to heat and a broad range of chemicals, fuels and solvents, fluoroelastomers are used in a wide variety of demanding automotive, aerospace, and industrial applications. These include seals, gaskets, liners, hoses, protective fabric coatings, diaphragms, roll covers, and cable jacketing.

Polysulfides – The polysulfide rubbers (T) are made by addition of organic halides to a hot aqueous solution of sodium polysulfide. With agitation, the polymer precipitates in the form of small particles which are then washed, coagulated and dried. Linear polysulfides are made by copolymerizing ethylene dichloride and di(chloroethyl) formal with the sulfur linkage. Branched polysulfides are made from di(chloroethyl) formal and 2% trichloropropane. Vulcanized polysulfides are used for their excellent combination of low temperature flexibility, gas and water impermeability, and resistance to ozone, sunlight, heat, weathering, and most oils, solvents and fuels. Linear polymers are cured by zinc oxide, with crosslinking at terminal hydroxy groups. Branched polymers are cured by peroxide (usually zinc peroxide) with crosslinking at terminal thiols. Liquid polysulfide polymers with thiol terminals are also produced. These can be cured at room temperature using peroxides or other oxygen donating curing agents to provide properties similar to the other polysulfide rubbers. The major applications for polysulfides are in products contacting fuels, solvents, or oils, and/or requiring low temperature flexibility and high impermeability to moisture and gases. These include sealants and putties, diaphragms and gaskets, roller coatings, hoses, potting compounds, anticorrosion coatings, and solid rocket fuel binders.

Epichlorohydrin Rubbers – These rubbers are the homopolymer of epichlorohydrin (CO) and the copolymer of epichlorohydrin and ethylene oxide (ECO). The chemically saturated polyether backbone plus the polar chloromethyl substituents provide a combination of excellent low temperature flexibility, good oil, solvent, fuel, ozone, and fire resistance, and high air impermeability. The homopolymer, with 38% chlorine, has better fluid resistance and flame retardancy. The copolymer, with 26% chlorine and the unsubstituted ethylene oxide groups in the backbone, has better low temperature flexibility. Vulcanization of these rubbers is by nucleophilic displacement of chlorine by a thiourea, triazine, or thiadiazole. The copolymer is also available with allyl glycidyl ether included as a curesite monomer, allowing peroxide or sulfur cures. Because of their characteristic attributes and moderate price (for a specialty elastomer), the epichlorohydrin rubbers are most widely used in automotive applications. These include seals, gaskets, hoses and tubing. Other applications are coated fabrics and roll covers.

Urethane Rubbers – Polyurethane elastomers are produced by reacting a diisocyanate, typically toluenediisocyanate or methylene di(4-phenyl)-isocyanate, with either a polyether polyol (e.g., 1,4-butanediol) or a polyester polyol (e.g., from adipic acid and ethylene glycol). The low molecular weight polyols produce hard polymers, while the high molecular weight polyols give soft polymers. A slight excess of polyol is used to provide hydroxy termination for peroxide cures. For sulfur-curing elastomers, some of the polyol is replaced with an unsaturated diol. The polyurethanes in general are characterized by high tensile strength and abrasion resistance combined with good oil and tear resistance. Urethane rubber is used in solid tires, seals, potting compounds, engineering mechanical goods, elastic thread, footwear, and sheets.

Polyacrylate Rubber – The acrylic elastomers (ACM) are poly(alkyl)acrylates. The alkyl groups can range from C_2 to C_8, but the most common acrylic monomers used are the ethyl, n-butyl, 2-methoxyethyl, and 2-ethoxyethyl acrylates. The polyacrylate rubbers generally contain a small amount of curesite monomer for versatility in crosslinking. This is typically a monomer with a reactive halogen (e.g., allylic chlorine), or in some cases an epoxide. With a chemically saturated backbone, the acrylic rubbers offer superior resistance to ozone, heat, UV light, and oxidation. The polar acrylate group provides resistance to oils, aliphatic solvents, and the sulfur-bearing lubricants which can crosslink unsaturated elastomers. These rubbers also offer superior flex life, impermeability to many gases, and good colorability. Applications include hoses, gaskets, seals and tank linings resistant to oils and high pressure (sulfur-containing) lubricants, as well as belting and fabric coatings.

SULFUR-BASED CURE SYSTEMS

Vulcanization, the introduction of crosslinks into the elastomer's polymer matrix, is a fundamental determinant of rubber properties. In short, it converts a substance that is plastic and moldable into one that is flexible and elastic. Vulcanization increases tensile strength, modulus (stiffness), hardness, abrasion resistance and rebound, and decreases elongation, hysteresis (heat buildup), compression set, and solubility. Except for tensile and tear strength, which usually show a specific optimum crosslink density, vulcanization-induced changes are proportional to the number of crosslinks and their length. Excessive crosslinking can convert the elastomer to a hard, brittle solid. Longer (polysulfide) crosslinks promote better tensile and tear strength and better fatigue properties. Shorter crosslinks provide better oxidative and thermal stability and lower compression set.

Sulfur is, by far, the most commonly used curing agent for elastomers with chemically unsaturated polymer backbones, particularly the more common diene rubbers: natural, SBR, polybutadiene, nitrile, polychloroprene, and polyisoprene. Other curing agents can be used with unsaturated elastomers, but sulfur dominates because it is low in cost and toxicity, broadly compatible with other compounding additives, and able to predictably provide the desired vulcanization properties. A typical sulfur vulcanization system is composed of sulfur, a metal oxide (usually zinc oxide), a fatty acid (to solubilize the oxide's metal) and one or more organic accelerators. Sulfur, nevertheless, will perform its crosslinking function even without promoters, as long as there is sufficient heat and time provided. Lacking the promoters, however, vulcanization could take many hours, or even days, while today's systems take only minutes.

Sulfur is available to the compounder in two forms: amorphous and rhombic. The amorphous form, also known as insoluble sulfur is a metastable high polymer that is insoluble in rubber and most solvents. Rhombic sulfur, a ring of eight sulfur atoms, is soluble in rubber and the form normally used for vulcanization. About 1 to 3 phr (parts per 100 parts of rubber elastomer) of sulfur are used for most rubber products. Vulcanization by sulfur alone is believed to be primarily via a thermally induced free-radical reaction. The sulfur will slowly react allylic to the site of unsaturation to form polysulfide substituents. These then are subject to heat-induced homolytic cleavage to thiyl (R-S·) and polysulfenyl (R-Sx·) free radicals, which in turn react with adjacent polymer chains to form monosulfide and (mostly) polysulfide links.

Activators

The rate at which sulfur reacts with unsaturated polymer can be accelerated by activators: a metal oxide plus fatty acid. The most common combination is zinc oxide and stearic acid, with the fatty acid solubilizing the zinc in the elastomer. It is believed that the sulfur reacts, in the presence of the metal, as a cation at the double bond. This results in charged and uncharged polysulfides, the latter of which could form free radicals. Metal activated vulcanization will proceed more rapidly than crosslinking by sulfur alone, but still too slow for most production purposes. The metal oxide/fatty acid is, in practice, used not to activate the sulfur itself, but to activate the organic compounds used as vulcanization accelerators.

Accelerators

Vulcanization accelerators, in simplest terms, hasten the cleavage of the sulfur ring and formation of thiyl and polysulfenyl radicals. The accelerators react in the form of their more active zinc salts, due to the nearly ubiquitous presence of zinc oxide in sulfur vulcanized compounds. The choice of accelerator will affect the scorch (premature vulcanization) safety, the cure rate, and the length and number of crosslinks which form. These properties, which are generally related to the speed with which the accelerator is converted to its very active salt form, are compared in Table 1.

Table 1. Accelerator Comparison

Accelerator Type	Scorch Safety	Cure Rate	Crosslink Length
None		very slow	very long
Guanidines	moderate	moderate	medium-long
Mercaptobenzothiazoles	moderate	moderate	medium
Sulfenamides	long	fast	short-medium
Thiurams	short	very fast	short
Dithiocarbamates	least	very fast	short

Acceleration was discovered in 1906 with the observation that addition of aniline to a sulfur/zinc oxide system significantly decreased vulcanization times. Dialkyl amines were also found to provide acceleration, and so aniline and the dialkyl amines were derivatized to the range of accelerators shown in Figures 2a and 2b. Aniline begat the guanidines, thiazoles, and sulfenamides (amine “blocked” forms of mercaptobenzothiazole). The amines begat the thiurams and dithiocarbamates. The thiazoles (MBT and MBTS) and the sulfenamides (CBTS, BBTS, MBS) account for most of current accelerator production, with the sulfenamides the more widely used. The superior scorch safety of the sulfenamides is provided by the time required to thermally decompose into MBT and amine.

While the sulfenamides are the most common primary accelerators, they are frequently used with secondary accelerators (a.k.a. “kickers”) which act as activators for the cure system. The thiurams and dithiocarbamates, which are short on scorch safety when used as primary accelerators, are used at relatively low levels to help activate the cure.

Retarders

The desired level of scorch safety can be obtained through use of scorch retarders in addition to the chosen accelerators. The traditional retarders are acids – benzoic acid, salicylic acid, phthalic anhydride – which interfere with the activity of the accelerators. These acids, however, do not only retard the scorch time, they also slow the cure rate and reduce the ultimate state of cure. With the widespread use of sulfenamide accelerators has come a new type of retarder which further improves upon these accelerators' superior scorch safety without significantly reducing cure rate or ultimate state of cure. For example, the retarder N-(cylcohexylthio)phthalimide will react with the MBT formed by the dissociation of the sulfenamide to form cyclohexyldithiobenzothiazole (CDB). The CDB is a good delayed action accelerator in its own right. It can be pictured as a sulfenamide analogue, with the cyclohexylthio group in place of an amine group. CDB, in turn, dissociates to accelerate the cure. The extended scorch safety derives from the total time required for the sulfenamide to dissociate, its liberated MBT to react with the retarder to form CDB, and the CDB to itself dissociate.

Figure 2a. Common Vulcanization Accelerators

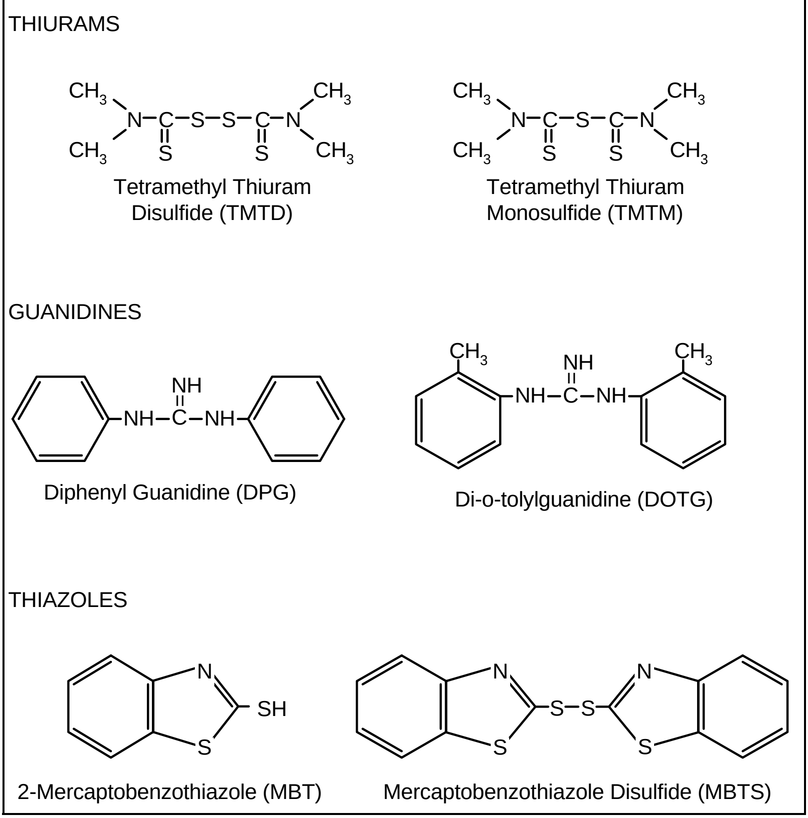
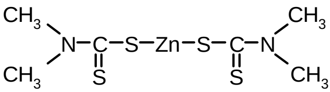
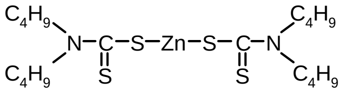


Figure 2b. Common Vulcanization Accelerators

DITHIOCARBAMATE SALTS

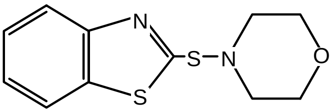


Zinc Dimethyldithiocarbamate

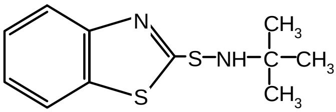


Zinc Dibutyldithiocarbamate

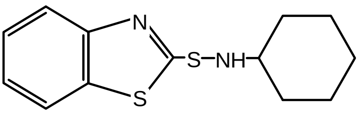
SULFENAMIDES



2-(Morpholinothio) Benzothiazole
Sulfenamide (MBS)



t-Butyl Benzothiazole
Sulfenamide (BBTS)



N-Cyclohexyl-2-Benzothiazyl
Sulfenamide (CBTS)

Crosslink Length

The length of the sulfide crosslinks formed during vulcanization affect rubber properties. Mono- and disulfide crosslinks are more stable (less prone to scission) than polysulfide links and so promote better thermal and aging characteristics. Polysulfide links, on the other hand, provide somewhat better molecular flexibility. This can result in better dynamic fatigue resistance. Physical properties aside, the more stable crosslinks are often preferred to provide reversion resistance. Reversion is the cleavage of sulfide crosslinks during vulcanization which results from extending the cure beyond the time required to obtain the desired optimized balance of vulcanizate properties. When overcured in this way, certain elastomers, particularly natural rubber, will revert to the soft, more plastic, less elastic condition characteristic of the uncured compound.

The choice of accelerator will influence the length of crosslinks, but this can be further controlled by adjusting the accelerator:sulfur ratio. Increasing this ratio progressively favors shorter crosslinks. This can be alternatively accomplished by using sulfur donors in place of most or all of the elemental sulfur for vulcanization. The thiuram accelerators, particularly the disulfides, and dithiodimorpholine are commonly used for this purpose. The use of a cure system designed to form predominately short crosslinks is referred to as efficient vulcanization (EV).

NON-SULFUR CURE SYSTEMS

Elastomers with chemically saturated backbones cannot be crosslinked with sulfur and so require alternate curing agents. The most widely used are the peroxides, which are also used with unsaturated elastomers. Metal oxides or difunctional compounds are used in special cases.

Peroxides

Peroxides cure by thermal decomposition into oxy radicals, which abstract a hydrogen from the elastomer to generate polymer radicals. These then react to form carbon-carbon crosslinks. With unsaturated elastomers, this occurs preferentially at the site of allylic hydrogens. The rate of crosslinking is directly proportional to the rate of decomposition of the peroxide. Cure rates and curing temperatures therefore depend on the stability of the peroxide, which decreases in the order dialkyl > perketal > perester or diaryl. The most commonly used of these crosslinkers is dicumyl peroxide.

Although carbon-carbon crosslinks are more thermally stable than sulfur crosslinks, they provide generally poorer tensile and tear strength. Peroxides are also incompatible with many of the antioxidants used in rubber, since the antioxidants are designed to scavenge and destroy oxy and peroxy free radicals (see Antioxidants, below). Peroxides cannot be used with butyl rubber because they cause chain scission and depolymerization.

Difunctional Compounds

Certain difunctional compounds are used to crosslink elastomers by reacting to bridge polymer chains. For example, diamines (e.g., hexamethylenediamine carbamate) are used as crosslinks for fluoroelastomers; p-quinone dioxime is oxidized to p-dinitrosobenzene as the active crosslink for bridging at the polymer double bonds of butyl rubber; and methylol terminated phenol-formaldehyde resins will likewise bridge butyl rubber chains (with $SnCl_2$ activation) as well as other unsaturated elastomers.

Metal Oxides

Metal oxides, usually zinc oxide but on occasion lead oxide for improved water resistance, are used as crosslinking agents for halogenated elastomers such as neoprene, halobutyl rubber, and chlorosulfonated polyethylene. The metal oxide abstracts the allylic halogen of adjacent polymer chains to form an oxygen crosslink plus the metal chloride salt.

FILLERS

A rubber compound contains, on average, less than 5 lbs. of chemical additives per 100 lbs. of elastomer. Filler loading is typically 10-15 times higher. Of the ingredients used to modify the properties of rubber products, the filler plays a dominant role. The term "filler" is misleading, implying, as it does, a material intended primarily to occupy space and act as a cheap diluent of the more costly elastomer. Most of the rubber fillers used today offer some functional benefit that contributes to the processability or utility of the rubber product. Styrene-butadiene rubber, for example, currently the highest volume elastomer, has virtually no commercial use as an unfilled compound.

Filler Properties

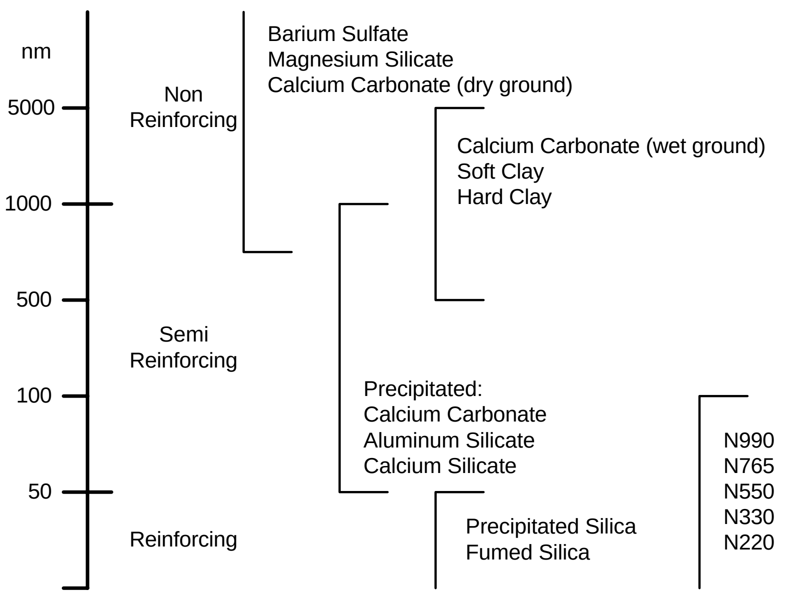
The characteristics which determine the properties a filler will impart to a rubber compound are particle size, surface area, structure, and surface activity.

Particle Size – If the size of the filler particle greatly exceeds the polymer interchain distance, it introduces an area of localized stress. This can contribute to elastomer chain rupture on flexing or stretching. Fillers with particle size greater than 10,000 nm (10 µm) are therefore generally avoided because they can reduce performance rather than reinforce or extend. Fillers with particle sizes between 1,000 and 10,000 nm (1 to 10 µm) are used primarily as diluents and usually have no significant affect, positive or negative, on rubber properties. Semi-reinforcing fillers, which range from 100 to 1000 nm (0.1 to 1µm) improve strength and modulus properties. The truly reinforcing fillers, which range from 10 nm to 100 nm (0.01 to 01 µm) significantly improve rubber properties.

Of the approximately 2.1 million tons of fillers used in rubber each year, 70% is carbon black, 15% is kaolin clay, 8% is calcium carbonate, 4% is the precipitated silicas and silicates, and the balance is a variety of miscellaneous minerals. Figure 3 classifies the various fillers by particle size and consequent reinforcement potential.

Most talcs and dry-ground calcium carbonates are degrading fillers because of their large particles size, although the planar shape of the talc particles contributes some improvement in reinforcement potential. The soft clays would fall into a class of diluent fillers that do not contribute reinforcement, yet are not so large that they degrade properties.

Figure 3. Filler Classification Chart



The hard clays contribute some reinforcement to rubber compounds, primarily because of their smaller particle size, and are normally classified as semi-reinforcing fillers. Ultrafine precipitated calcium carbonates also fit into the semi-reinforcing class. The carbon blacks and precipitated silicates and silicas are available in various particle sizes that range from semi-reinforcing to highly reinforcing. They generally exist as structural agglomerates or aggregates rather than individual spherical particles.

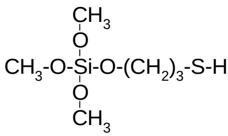
Surface Area – Particle size is generally the inverse of surface area. A filler must make intimate contact with the elastomer chains if it is going to contribute to reinforcement. Fillers that have a high surface area have more contact area available, and therefore have a higher potential to reinforce the rubber chains. The shape of the particle is also important. Particles with a planar shape have more surface available for contacting the rubber than spherical particles with an equivalent average particle diameter. Clays have planar-shaped particles that align with the rubber chains during mixing and processing, and thus contribute more reinforcement than a spherical-shaped calcium carbonate particle of similar average particle size. Particles of carbon black or precipitated silica are generally spherical, but their aggregates are anisometric and are considerably smaller than the particles of clay. They thus have more surface area per unit weight available to make contact with the polymer. Rubber grade carbon blacks vary from 6 to 250 m^2/g. Most reinforcing precipitated silicas range from 125 to 200 m^2/g; a typical hard clay ranges from 20 to 25 m^2/g.

Structure – The shape of an individual particle of reinforcing filler (e.g. carbon black or precipitated silica) is of less importance than the filler's effective shape once dispersed in elastomer. The blacks and precipitated inorganics used for reinforcement have generally round primary particles but function as anisometric acicular aggregates. The round particles clump together into chains or bundles that can be very dense or open and lattice-like. These aggregate properties – shape, density, size – define their structure. A high structure filler has aggregates favoring high particle count, with those particles joined in chain-like clusters from which random branching of additional particle chains may occur. In simplest terms, the more an aggregate deviates from a solid spherical shape and the larger its size, the higher is its structure. The higher its structure, in turn, the greater its reinforcing potential

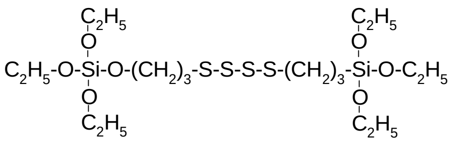
For reinforcing fillers which exist as aggregates rather than discreet particles, carbon black and silica in particular, a certain amount of structure that existed at manufacture is lost after compounding. The high shear forces encountered in rubber milling will break down the weaker aggregates and agglomerates of aggregates. The structure that exists in the rubber compound, the persistent structure, is what affects processability and properties.

Surface Activity – A filler can offer high surface area and high structure, but still provide relatively poor reinforcement if it has low specific surface activity. The specific activity of the filler surface per cm^2 of filler-elastomer interface is determined by the physical and chemical nature of the filler surface in relation to that of the elastomer. Nonpolar fillers are best suited to nonplar elastomers; polar fillers work best in polar elastomers. Beyond this general chemical compatibility is the potential for reaction between the elastomer and active sites on the filler surfaces. Carbon black particles, for example, have carboxyl, lactone quinone, and other organic functional groups which promote a high affinity of rubber to filler. This, together with the high surface area of the black, means that there will be intimate elastomer-black contact. The black also has a limited number of chemically active sites (less than 5% of total surface) which arise from broken carbon-carbon bonds as a consequence of the methods used to manufacture the black. The close contact of elastomer and carbon black will allow these active sites to chemically react with elastomer chains. The carbon black particle effectively becomes a crosslink. The non-black fillers generally offer less affinity and less surface activity toward the common elastomers. This can be compensated for to some extent by certain surface treatments.

Figure 4. Silanes Used With Sulfur Cure



Mercaptosilane



Tetrasulfide Silane

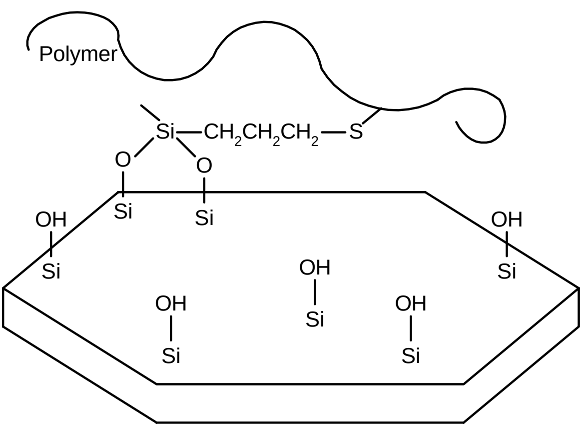
All of the non-black, non-carbonate reinforcing or semi-reinforcing fillers have one feature in common. The clays, silicas, and silicates all have surface silica (SiO_2) groups which have hydrolyzed to silanols (-SiOH). These silanol groups behave as acids ($-SiO^-H^+$) and are chemically active. The higher surface area fillers have more silanols available and are thus more reactive. One effective means to modify the surface chemistry of non-black fillers is by the addition of silane coupling agents. These react with the silanols on the filler surface to give a strong bond, and also contain a functional group that will bond to the rubber during vulcanization. The result is filler-polymer bonding (crosslinking) that increases modulus and tensile strength and improves abrasion resistance. Modification of the filler surface also improves wetting and dispersion. The silane coupling agents are expensive, and as a result they are used mostly in higher priced rubber compounds, primarily to promote maximum abrasion resistance.

There are two silane coupling agents commonly used with non-black fillers in sulfur-cured compounds. These are mercaptosilane and tetrasulfide silane, shown in Figure 4. The methoxy or ethoxy groups react during mixing with the silanol groups on the surface of silica, silicate, or clay particles to give a strong bond. The sulfur-containing group of each structure reacts during vulcanization to give bonding to the polymer.

The mercaptosilane is more active on a phr weight basis. About 1.5 to 2.0 times as much tetrasulfide silane is required to achieve similar modulus and abrasion resistance levels. The mercaptosilane has a strong mercapto odor that makes working with the neat liquid product unpleasant. It is normally used as a concentrate carried on an inert carrier, or in the form of pretreated filler.

The silane coupling bond is depicted in Figure 5. The chemistry of the bond would be similar whether the filler was a clay pretreated with mercaptosilane or a high surface area silica that had the silane added during mixing. The addition sequence is very important when adding silane coupling agents during mixing of the compound, especially when using the tetrasulfide. To make the most efficient use of these high-cost chemicals, it is important to mix the polymer, filler, and silane coupling agent for 1 to 2 minutes before adding any other ingredients that will interfere with the reaction between the filler and the silane. If the mixing temperature gets too high (above about 150 to 160^{o}C) the tetrasulfide group can be broken prematurely, reducing its ability to bond to the polymer during vulcanization.

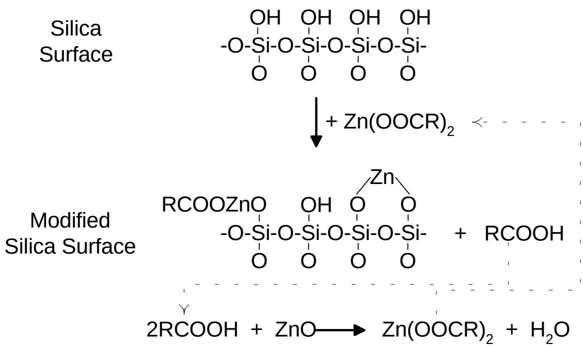
Figure 5. Silane Coupling



Silanes with other functional groups such as amino, vinyl, methacryl, or epoxy groups are also used, primarily with non-sulfur cure systems. The functional group is tailored to the type of cure system to maximize bonding to the polymer during vulcanization.

Silanols show similarities to carboxylic acid groups in their reactions with amines, alcohols, and metal ions. While water adsorbed on the surface of filler particles will reduce silanol reactivity, hot compounding volatilizes some of this water, leaving a very reactive surface. Some of the reactions with silanols can have a profound effect on the properties of the rubber compound, especially where the chemical involved is an important part of the cure system. Most of the accelerators used in sulfur cure systems contain an amine group. Strong adsorption or reaction with filler particles can decrease the amount of accelerator available for vulcanization reactions. This can give slower cure rates and a reduced state of cure. Similar effects can result from the reaction of zinc ions with filler particles. For example, the active silanols on the surface of a precipitated silica particle will react with zinc stearate to give two known reaction products: one is a zinc stearate complex, and the other is a bridging of zinc across two silanol groups, as shown in Figure 6.

Figure 6. Soluble Zinc Reaction With Silica



Excess stearic acid is released to combine with more zinc oxide. If allowed to proceed to completion, this mechanism would eventually rob all the zinc, leaving none to activate the vulcanization reaction. Lower surface area non-black fillers also react with the zinc ion, but show less effect because they have fewer silanol groups available.

These negative effects on the cure system can be reduced or completely avoided by adding other chemicals that will tie up the silanol groups and reduce their activity. Such additives commonly used in non-black compounds include diethylene glycol (DEG) and polyethylene glycol (PEG), hexamethylene tetramine (Hexa), hexamethoxy methyl melamine (HMMM), and triethanolamine (TEA). These are mixed into the compound prior to the addition of the zinc oxide and accelerators. Magnesium oxide in nitrile and neoprene compounds also reduces the tendency for the fillers to rob zinc from the cure system.

Many of these additives also reduce the polarity of the filler surface and thus improve wetting and dispersion in non-polar polymers. Polar oils or aromatic resins also generally improve filler dispersion and the properties of compounds containing non-black fillers. Other techniques used to adjust the cure of compounds containing non-black fillers include increasing the level of amine accelerators and adding zinc oxide in a second mixing stage.

Filler Effects

The principal characteristics of rubber fillers – particle size, surface area, structure, and surface activity – are interdependent in improving rubber properties. In considering fillers of adequately small particle size, reinforcement potential can be qualitatively considered as the product of surface area, surface activity, and persistent structure or anisometry (planar or acicular nature).

The general influence of each of these three filler characteristics above on rubber properties can be summarized as follows:

1. Increasing surface area (decreasing particle size) gives lower resilience and higher Mooney viscosity, tensile strength, abrasion resistance, tear resistance, and hysteresis.

2. Increasing surface activity (including surface treatment) gives higher abrasion resistance, chemical adsorption or reaction, modulus (at elongation >300%), and hysteresis.

3. Increasing persistent structure/anisometry gives higher Mooney viscosity, modulus (at elongation <300%), and hysteresis, lower extrusion shrinkage, tear resistance, and resilience, and longer incorporation time.

In general terms, the effect of a filler on rubber physical properties can be related mainly to how many polymer chains are attached to the filler surface and how strongly they are attached. Filler surface area and activity are the main determinants, supplemented by structure. Since the filler particles can be considered crosslinks for the elastomer chains, the presence or absence of a coupling agent on the surface of non-black fillers is also important.

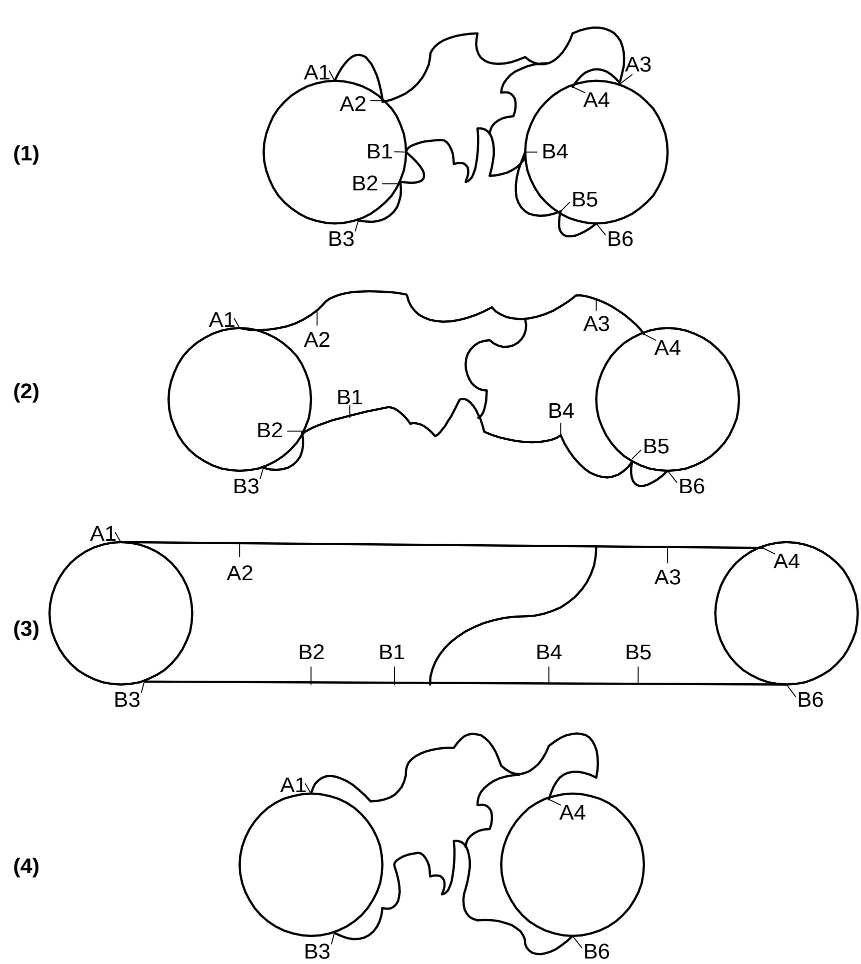
Modulus/Tensile Strength – Modulus is a measure of the force required to stretch a defined specimen of rubber to a given percent elongation. Most often, modulus is reported at 300% elongation (four times original length). This can be alternatively viewed as the resistance to a given elongating force. For an uncompounded elastomer, elongation is primarily a function of stretching and disentangling the randomly oriented polymer chains and breaking the weak chain-chain attractions. Vulcanized, but unfilled, elastomers more strongly resist elongation because the sulfur crosslinks must be stretched and broken to allow chain extension and separation. The introduction of a filler into the vulcanizate provides further resistance to elongation. A filler with low surface activity will increase resistance to elongation by the viscous drag its surface provides to the polymer trying to stretch and slide around it. Higher surface area, greater anisometry or structure, and higher loading (the latter two effectively increasing the surface area exposed to the elastomer) will all increase the modulus. Fillers with strong chain attachments, via active sites or coupling agents, provide the most resistance to the chain extension and separation required for elongation.

It is helpful to visualize the filler particles acting as giant crosslinks. Figure 7 is a schematic representation of such a system with the filler particles simplified to spheres for convenience. Before stretching (Step 1), the polymer chains are in random configuration. Chains A, B and C have multiple points of attachment to the filler particles, corresponding to the latter's active sites. On elongation, resistance is supplied as the energy required to detach the chain segments from these active sites (Step 2 and 3). The amount of energy required to attain maximum elongation, and then required to overcome the stress distribution implied in Step 3 to cleave chain-chain and chain-filler attachments, likewise explains the higher tensile strength (force required for elongation to sample rupture) of a system of this type.

After the elongating force has been removed, the elastomer chains return to their preferred random orientation (Step 4), except that now they have the minimum number of points of attachment to the filler as a consequence of having been extended, as in Step 3. Less force would now be required to return these chains to ultimate extension, because the intermediate points of attachment that existed in Steps 1 and 2 have been eliminated. This accounts for the phenomenon known to rubber technologists as stress softening. With repeated stress-relaxation cycling, a decrease in modulus from the initial maximum is obtained. Stress softening is a temporary effect. After a period without strain, the rubber will recover to near its original modulus, as the active filler sites again attach to polymer segments. A percentage of the original modulus is permanently lost, however, due to irrecoverable chain and bond cleavage.

Hardness/Flexural Strength – The analogous resistance to elastomer chain deformation accounts for the increase in rubber hardness obtained in proportion to filler loading, surface area, structure activity/surface treatment, and structural anisometry. Hardness is typically measured as resistance to surface indentation under specific conditions, so the force is supplied as a point of compression rather than an area of tension. Similar filler particle dynamics apply, nevertheless.

Figure 7. Filler Crosslinking



Flexural strength is likewise related as a measure of a sample's resistance to deformation (flex) under a compressive force. With a force supplied to an end-supported test sample, the upper surface is under compression and the lower surface is in tension (elongation). Both compression and elongation are effectively resisted in proportion to the durability of the filler-elastomer bond. High structure or anisometric fillers provide greater resistance to compression because this force is generally perpendicular to their more rigid planar or elongate dimension.

Impact Strength – Impact strength or impact resistance is the measure of a hard rubber's resistance to fracture under sudden impact. The impact force is one of compression on one side of the rubber and tension on the other, so that fracture is a result of failure similar to that occurring when a tensile sample is elongated to break. The same filler-elastomer consideration as in tensile and flexural testing therefore apply.

Tear Strength/Flex Resistance – Tear strength and flex resistance are essentially a measure of resistance to crack or slit propagation. Both typically measure the growth of a crack under tension, although flex testing, with multiple flexing cycles, introduces the additional factor of heat generation and fatigue. Large or poorly bound fillers will act as flaws and initiate or propagate cracks under test conditions. Small particle size, high surface area, and high surface activity allow the filler particles to act as barriers to the propagation of microcracks, and provide the higher tensile strength required to resist failure.

Resilience/Hysteresis – Resilience is essentially a measure of rubber elasticity – the characteristic ability to quickly return to original shape following deformation. Unfilled elastomers are at their peak resilience because there is no obstacle to elastomer chain extension and contraction (return to randomness). The introduction of a filler creates such an obstacle in proportion to the strength of the particle-polymer interaction. Resilience is therefore generally in inverse proportion to filler loading and reinforcement.

If resilience is considered the ratio of energy release on recovery to the energy impressed on deformation, hysteresis can be viewed as a measure of the amount of impressed energy that is absorbed. An unfilled (elastic) elastomer will convert most of the energy of deformation into the mechanical energy used in returning to the original shape. The degree to which input energy is converted to heat, due to friction from polymer chains sliding past each other, is a function of polymer chain morphology. All fillers increase the hysteresis of rubbers, the most reinforcing fillers generally producing the largest increases. This is due to the energy consumed in polymer-filler friction and in dislodging polymer segments from active filler surfaces. This is heat energy which would otherwise have a mechanical manifestation as elastic rebound. In short, hysteresis is inversely related to resilience.

Abrasion Resistance – Abrasion resistance is a function of filler structure, particle size, and surface activity (filler-elastomer adhesion). At equivalent loadings, large particles will be more easily dislodged from the rubber surface than finer particles. Finer particle sizes also provide more uniform distribution and more particles per unit surface area. Loss of a larger particle will expose more of the relatively soft surrounding elastomer matrix to wear. The effect is acute on the edge of the depression left by the dislodged filler particle. This is the area most susceptable to elongation, crack initiation and ultimate loss. For a fine filler, the better the rubber-particle bond, the more difficult it will be to dislodge. Abrasion resistance under dynamic conditions is also affected by compound hysteresis which, in turn, is a function of filler selection.

The classic illustration of the role of hysteresis vs. resilience in abrasion resistance is wear resistance of tire treads. The tread is deformed at the area of contact with the road. Wear comes from the sliding of the rubber across the road just to the rear of the area of contact. This sliding occurs during elastic recovery of the deformation. Greater resilience would give quicker recovery and this would expose greater tread area to sliding and consequent wear. A tread compound with greater hysteresis will inhibit elastic recovery and thereby decrease the area of sliding and the amount of wear. This must be balanced against the ability of the tread to recover sufficiently to again deform and dissipate heat with the conclusion of one revolution, otherwise heat buildup will be excessive.

Filler Types

The use of fillers in rubber products is nearly as old as the use of rubber itself. Whether the initial motivation was function or economics is not known. Prior to the discovery of vulcanization, the tackiness of rubber goods was subject to correction by the traditional remedy for wet or sticky surfaces – sprinkling with talcum powder. The technological leap from talc on the outside to incorporation of talc on the inside of the rubber to serve the same purpose is credible. Hancock’s masticator, and the rubber mixing machinery it spawned, facilitated the incorporation of all types of fine particulates, including ground limestone, clays, barite, zinc oxide, zinc sulfide, iron oxides, asbestos, mica, litharge (lead oxide) and kieselguhr (diatomite). Whether the original reason for adding these powders was reduction in tack, adjustment of color, or simply reducing the cost of the rubber compound, two conclusions were inevitably drawn. Some fillers could be added in large amounts without detracting from desirable rubber properties, and others would actually improve rubber properties, usually by increasing hardness and durability.

In time, the fillers which were likely first used for their color, zinc oxide and carbon black, became recognized for their reinforcement potential. In the early years of the 20th century, prior to World War I, zinc oxide was the most widely used reinforcing filler in rubber; the abrasion resistance it provided made it the preferred filler in tire treads. It was also during this period that zinc oxide was discovered to be the activator for the newly emerging organic accelerators. The reinforcing effect of carbon black was quantified during the first decade of this century, but remained unexploited for about ten years. The zinc oxide-filled tire tread invariably outlasted the canvas-based carcass, so any improvements offered by black-filled tread were less than compelling. It was only after B.F. Goodrich Co. purchased the patent rights to tire carcass cord and acquired carbon black compounding technology in 1912 that reinforcement requirements changed. The more durable carcass construction allowed room for improvement in tread wear. By the end of World War I, carbon black had widely displaced zinc oxide in pneumatic tire treads, although it took more than five years thereafter for the tire manufacturers to convince the general public that black tires were better than white.

Zinc oxide filler use eroded further in the 1930s with the introduction of precipitated calcium carbonate, and was all but eliminated in the 1940s with the development of precipitated calcium silicate and precipitated silica. Carbon black, meanwhile, became firmly established as the premier reinforcing filler.

Carbon Black – Carbon black is essentially elemental carbon in the form of fine amorphous particles. Each particle is composed of randomly oriented microcrystalline layered arrays of condensed carbon rings. Because of their random orientation, many arrays expose open layer edges with unsatisfied carbon bonds at the particle surface. This in turn provides the sites for chemical activity. Individual round carbon black particles do not exist as discrete entities but form aggregates, which may be clumps or chains of various sizes and configurations. The functional carbon black “particle”, therefore, is actually the aggregate. Average particle size and aggregate configuration (structure) are the major determinants of the utility of a given carbon black in a specific rubber compound. The major differences among commercial grades result from control of these averages.

Prior to World War II, the predominant reinforcing black was made from small natural gas flames impinging on iron channels. The deposit scraped from these channels was known as channel black. The finest particle size used for rubber, about 24 nm average, was Hard Processing Channel (HPC) because it produced the stiffest stocks. Larger particles sizes were available as Medium Processing Channel (MPC) at 26 nm average, and Easy

Processing Channel (EPC) at 29 nm average. Channel blacks are no longer used in rubber because of their high cost and the availability of suitable alternatives.

Furnace blacks began displacing channel blacks for rubber reinforcing in the early 1940s. Furnace blacks were at first, as early as the 1920s, made by burning natural gas in large horizontal furnaces, yielding a relatively coarse (60 to 80 nm average) semi-reinforcing product. Synthetic rubber development during World War II, particularly the reinforcemnt requirements of the otherwise unusable SBR, promoted the production of finer grades. Ultimately, natural gas was abandoned as a feedstock in favor of residual aromatic petroleum oils. This liberated carbon black manufacture from proximity to natural gas sources and allowed location of plants more convenient to the consuming industries. Oil furnace blacks today account for about 95% of the carbon black used in rubber.

The thermal process, introduced in 1922, makes the largest particle size and lowest structure blacks. Thermal blacks are made in a large cylindrical furnace by the thermal decomposition of natural gas in the absence of flame or air. Thermal blacks range from 100 to 500 nm average and are generally used as low cost functional extender fillers. Their relatively large size and low structure enable higher loadings and provide better resilience and lower hysteresis than the more reinforcing blacks.

The carbon blacks that provide the highest ratio of reinforcement to surface area are those produced using the shortest reaction time. Short reaction time promotes randomness of carbon ring layer orientation within the particle and the consequent occurrence of layer edges, with unsatisfied carbon bonds, at the surface. Furnace black production accomodates the manipulation of reaction time and conditions that results in some degree of tailoring of product surface activity. Heat-treating (graphitizing) high activity blacks has shown a marked reduction in surface activity. This is believed due to the realigning of carbon layers such that the maximum number of carbon-carbon bonds are formed and the layer planar surfaces rather than the edges are exposed at the particle surface. The production of thermal blacks requires a sufficiently long reaction time that they are largely graphitized in this way. Thermal blacks consequently provide characteristicaly low surface activity and reinforcement potential.

Until 1968, carbon black nomenclature was informal and based on a variety of characteristics, including level of abrasion resistance, level of reinforcement, vulcanizate modulus, processing properties, general usefulness, particles size, and electrical conductivity. In 1968, the ASTM Committee on Carbon Black established a common nomenclature system consisting of a prefix followed by a three digit number. The prefix is either N, for normal curing, or S for slow curing. At the time, rubber grade channel blacks, which are slow curing, were still used. They have since been discontinued; all current rubber grade blacks carry the N prefix.

The first of the three digits indicates a range of average particle size in nanometers. The second and third digits are assigned by the ASTM Committee to new products as they are developed. In general, lower structure blacks are assigned lower numbers and higher structure blacks, higher numbers, although there are some exceptions. Table 2 shows carbon blacks by ASTM classification, the old letter classification and size ranges.

Table 2. - Carbon Blacks

ASTM Series Classification	Old Classification	Size Avg, (nm)
N100	SAF (Super Abrasion Furnace)	11 to 19
N200	ISAF (Intermediate Abrasion Furnace)	20 to 25
N300	HAF (High Abrasion Furnace)	26 to 30
N400	FF (Fine Furnace)	31 to 39
N500	FEF (Fast Extruding Furnace)	40 to 48
N600	GPF (General Purpose Furnace)	49 to 60
N700	SRF (Semi-Reinforcing Furnace)	61 to 100
N800	FT (Fine Thermal)	101 to 200
N900	MT (Medium Thermal)	201 to 500

Kaolin Clay – Kaolin clay is typically used to reduce rubber compound cost while improving physical or processing properties. Rubber filler clays are classified as either “hard” or “soft” in relation to their particle size and stiffening affect in rubber. A hard clay will have a median particle size of approximately 250 to 500 nm, and will impart high modulus, high tensile strength, stiffness, and good abrasion resistance to rubber compounds. Soft clay has a median particle size of approximately 1000 to 2000 nm and is used where high loadings (for economy) and faster extrusion rates are more important than strength.

The anisometry (planar shape) and particle size of the clays account for their affect on modulus and hardness. More hard clay than soft is used in rubber because of its semi-reinforcing effect and its utility as a low cost complemenent to other fillers. It is used to improve the tensile and modulus of ground calcium carbonate compounds and will substitute for a portion of the more expensive carbon black or precipitated silica in certain compounds without sacrificing physical properties.

Most of the clay used in rubber is airfloat. Some water-washed clay is used because its lower level of impurities provides better color and less die wear with extrusions. Aminosilane and mercaptosilane treated hard clays provide better reinforcement than untreated clay, and in some applications can rival furnace blacks. The combination of platey morphology and chemical reactivity enable the silane-treated kaolins to impart a unique blend of properties to elastomers. These include high modulus, low hysteresis, good abrasion resistance, low viscosity, low set, and resistance to heat and oxidative aging. The combination of high modulus and low hysteresis, in particular, have earned them a place alone or as a partial carbon black replacement in products requiring good dynamic properties. These include transmission and V-belts, as well as non-tread tire components.

Calcined clay and delaminated clay are also used in rubber. The former is used mostly in wire and cable coverings where it provides excellent dielectric and water resistance properties, although poor reinforcement. Delaminated clay is individual clay platelets instead of the platelet stacks characteristic of other clay products. As such it represents the most planar or anisometric form of clay available and imparts particularly high stiffness and low die swell.

Calcium Carbonate – Calcium carbonates for rubber, often referred to as "whiting", fall into two general classifications. The first is wet or dry ground natural limestone, spanning average particle sizes of 5000 nm down to about 700 nm. The second is precipitated calcium carbonate (PCC) with fine and ultrafine products extending the average size range down to 40 nm.

Ground natural products show low anisometry (specific shape depends on grinding process), low surface area and low surface activity. They are widely used in rubber, nevertheless, because of their low cost, and because they can be used at very high loadings with little loss of compound softness, elongation or resilience. This all follows from the relatively poor polymer-filler adhesion potential, as does poor abrasion and tear resistance. Dry-ground limestone is probably the least expensive compounding material available and more can be loaded into rubber than any other filler. Water-ground limestone is somewhat more expensive, but offers better uniformity and finer particles size.

The much smaller size of precipitated calcium carbonates provides a corresponding increase in surface area. The ultrafine PCC products (<100 nm) can provide surface areas equivalent to the hard clays. Manipulation of manufacturing conditions allows the production of precipitated calcium carbonates of two distinct particle shapes. Precipitated calcites are essentially isometric particles, while precipitated aragonites are acicular. Precipitated calcite is the form generally used in rubber compounding.

Stearate-treated versions of both the ground and precipitated calcium carbonates are available. The surface coating controls moisture absorption, improves dispersion, promotes better elastomer-particle contact, and protects the calcium carbonate from decomposition by acidic ingredients or compounding reaction products. Since calcium carbonate offers no reactivity toward silanes, analogues to the silane treated clays and synthetic silicas do not exist. There is, however, an ultrafine PCC with a reactive surface coating of chemically bonded carboxylated polybutadiene polymer. With either sulfur or peroxide vulcanization, crosslinking occurs between the elastomer and the carboxylated polybutadiene coating. This provides the highest level of reinforcement among the PCC products, comparable to thermal blacks.

Precipitated Silica – Precipitated silica is an amorphous form of silicon dioxide produced by reacting sodium silicate solution with either sulfuric acid or a mixture of carbon dioxide and hydrochloric acid. The discreet silica particles which initially form – the primary particles – fuse into aggregates, which in turn form loose agglomerates. The precipitate is filtered, washed of residual sodium sulfate or sodium chloride, dried, and milled. Like the carbon blacks, the precipitated silicas used in rubber are bought as agglomerates, which after milling exist in the elastomer as aggregates. The particles size reported for precipitated silica products is typically that of the primary particles (10 to 30 nm) rather than the aggregates (30 to 150 nm) which are the functional particles. Surface area (BET) is therefore frequently used in place of particle size to classify the various grades.

Precipitated silicas are also classified according to structure, which is a function of the manipulation of primary particle size and aggregate water pore volume during manufacture. For convenience, structure has been related to oil absorption as given in Table 3, although oil absorption is generally proportional to surface area. Fully reinforcing silicas for elastomers would be characterized as high structure or very high structure with surface areas at or above about 150 m^2/g and oil absorption at or above about 200ml/100g.

Despite similarities in size and structure between precipitated silicas and carbon blacks, fundamental differences in surface activity exist. The silica surface is highly polar and hydrophilic and contains adsorbed water. The surface hydroxyl groups are acidic and tend to retard cure rate. The adsorbed moisture volatilizes at compounding temperatures. The tendency of silica surfaces to react with the zinc oxide activator was discussed previously. High molecular weight polyethylene glycols are the most common additives used with precipitated silicas to reduce their reactivity toward zinc oxide and organic accelerators, and to reduce their polarity.

Table 3. Definition of Precipitated Silica Structure

Silica Structure Level	Oil Absorption (ml/100g)
VHS	> 200
HS	175-200
MS	125-175
LS	75-125
VLS	<75

The use of additives to make the surface of precipitated silica less hydrophilic and more "rubberphilic" facilitates incorporation, dispersion, and more intimate filler-elastomer contact during compounding. This provides an improvement in rubber physical properties, as would be expected from a high surface area, high oil absorption filler. However, reinforcement comparable to that obtained with carbon black requires a polymer-filler bonding mechanism comparable to that provided at the carbon black active sites. With precipitated silicas, this comes by way of a reactive silane.

Common practice has been to use the functional silanes as separate compounding ingredients. This necessitates careful control of addition sequence and procedures because the silane must react with the silica surface in preference to all other components in order to be optimally effective. Aggresive competitors for the silica surface are amines, glycols, resins, metal oxides, and other silica particles (agglomeration). Precipitated silicas pretreated with silane are now available to simplify compounding. The pretreatment also makes the silica less hydrophilic, for easier dispersion and lower viscosity

Miscellaneous Fillers – Although kaolin clay, calcium carbonate, and precipitated silica account for most of the non-black fillers used in rubber today, there are a number of other fillers routinely used for their low cost or unique funtionality.

Talc – Although widely used as a reinforcing filler in plastics, relatively little talc is used for this purpose in rubber. Platy talcs are white, hydrophobic, and alkaline, with greater anisometry than kaolin clay. They are readily treated with silanes and other coupling agents. However, they tend to be too large in particle size for effective elastomer reinforcement. Micronized talcs with median particle size of 1 to 2 microns and essentially all particles <10 microns are available and are used, although they compete with the generally less expensive clays.

Barite – Barite, ground natural barium sulfate, is used in acid resistant compounds because of its inertness, and as a high gravity filler where weight is desired. It has little effect on cure, hardness, stiffness, or aging. Precipitated barium sulfate, also known as blanc fixe, is available in fine enough particle size to be semi-reinforcing. It provides the same softness and resilience as barite but better tensile strength and tear resistance.

Diatomite – As silica, diatomite is chemically inert, but its high adsorptive capacity for accelerators can affect cure. It imparts stiffness, hardness and low die swell. Diatomite is used as a filler in silicone rubber, and because of its adsorptive capacity, as a process aid in high oil rubber compounds.

Mica – Because of its platey nature and high aspect ratio, mica is occasionally used as a filler or semi-reinforcer, depending upon particle size.

Fumed Silica – Fumed silica is generally finer in primary particle size and higher in surace area than precipitated silica. As a reinforcing agent, it provides an aggregate structure similar to that of carbon black and precipitated silica. Due to its pyrogenic manufacture, it has lower moisture content and fewer surface hydroxyls than precipitated silica. Its high price confines it to premium applications, particulary silicone rubbers. Surface treated grades are available.

Precipitated Silicates – These products are coarser and less structured than the precipitated silicas and, as such, are only semi-reinforcing, but can be used at high loadings. Precipitated calcium silicate and precipitated sodium aluminum silicate are the most common alternatives.

ANTIDEGRADANTS

The proper choice of elastomer, cure system and filler will ensure that the desired properties are obtained from a rubber product. Antidegradants are used to prevent these properties from changing during service. The primary degradant effects are oxidation and ozone attack.

There are certain general criteria, beyond cost, guiding the selection of antioxidants and antiozonants. The volatility of the antidegradant determines its potential for loss during compounding and service, which in turn affects the rubber product's maximum service life. The solubility of the antidegradant is important, since it will ideally be soluble in the rubber compound, but insoluble (unextractable) in any liquids the product will routinely contact. Chemical stability is essential to maximum product service life. This includes stability to heat, light, oxygen and other compounding additives. Volatility, solubility, and stability are all involved in determining whether or not the antidegradant is considered discoloring or staining. Discoloration refers to the color imparted to the rubber itself, and is an issue only for non-black stocks. Staining is discoloration imparted to another surface in contact with or near the rubber article.

Antioxidants

Most elastomers are subject to oxidation, although unsaturated polymers oxidize more readily than saturated polymers. Oxidation is a cyclic free radical chain process that proceeds by two mechanisms. Chain scission of the polymer backbone causes softening and weakening. Radical-induced crosslinking causes hardening and embrittlement. In most cases, both mechanisms occur, and the one which predominates determines compound properties. Chain scission, for example, is the primary mechanism in natural rubber while crosslinking is predominant with SBR. Heat, UV light, humidity, and pro-oxidant metal ions (eg. copper, iron, manganese, cobalt) will each accelerate oxidation.

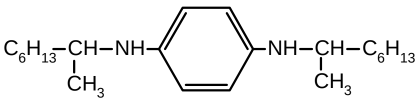
Oxidation is initiated by the formation of carbon radicals as a result of chain cleavage. The carbon radicals add oxygen to form peroxy radicals. These abstract hydrogens from the rubber to form hydroperoxides and generate the additional carbon radicals which continue the cycle. The hydroperoxides decompose into two oxy radicals (R-O· + ·OH) which just accelerate the oxidative degradation.

Primary antioxidants scavenge radicals before they can react with the elastomer. They can be generally classed as secondary amines and substituted phenols with very reactive hydrogens. More specifically, the primary antioxidants can be categorized and differentiated as in Figure 8. The aromatic amines are the most effective primary antioxidants, but are also discoloring. Of these, the diphenylamines and polymeric dihydroquinolines are the least discoloring while the p-phenylene diamines (PPDs) are highly discoloring. The PPDs, nevertheless, are the most commonly used antidegradants because they are also antiflex agents, metal ion deactivators, and antiozonants. The phenolic antioxidants are usually used in non-black compounds where the amine antioxidants cannot be used. The phenolics can produce colored reaction products, but the discoloration is significantly less than produced by the amines. The hindered bisphenols are the most effective, and the most expensive. Certain mercaptoimidazoles and dithiopropionates are used as synergists with the primary antioxidants.

Figure 8. Primary Antioxidants

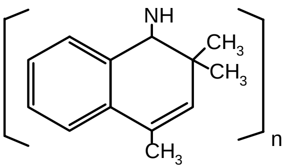
STAINING / DISCOLORING

SUBSTITUTED PARAPHENYLENEDIAMINES



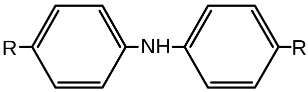
N,N'-Bis(1-methylheptyl)-p-phenylenediamine

POLYMERIZED DIHYDROQUINOLINES



Poly-2,2,4-trimethyl-1,2-dihydroquinoline

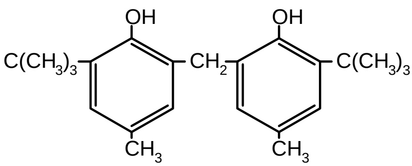
DIPHENYLAMINE DERIVATIVES



Alkylated diphenylamine

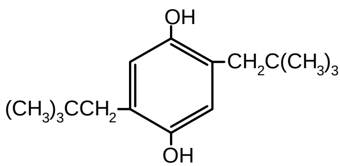
NON-STAINING / NON-DISCOLORING

HINDERED BISPHENOLS



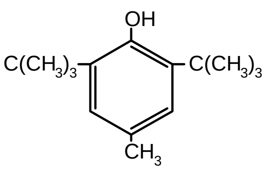
2,2'-Methylenebis(4-methyl-6-*t*-butylphenol)

SUBSTITUTED HYDROQUINONES

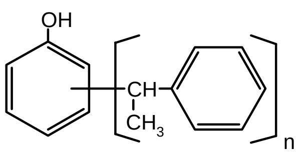


2,5-Di-t-amylhydroquinone

HINDERED PHENOLS



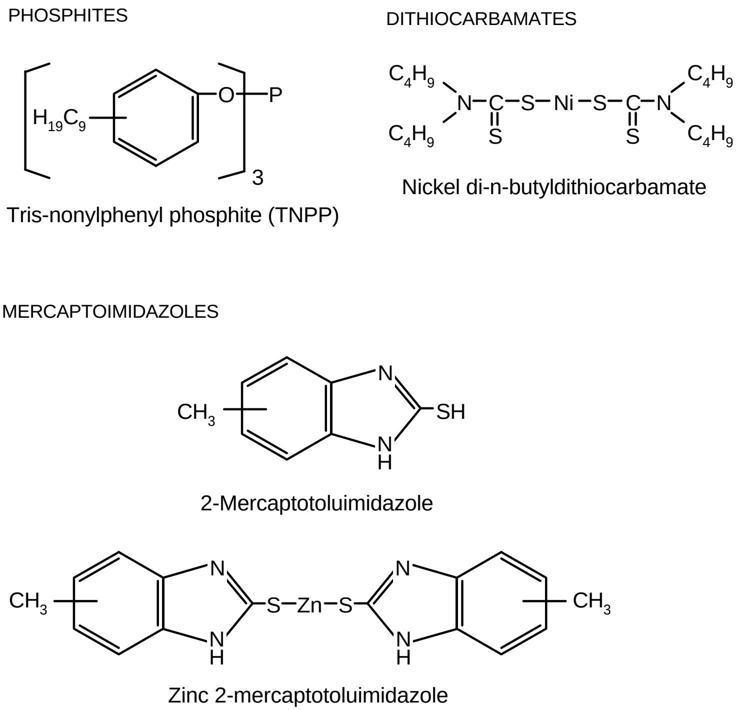
2,4-Di-*t*-butyl-4-methylphenol (BHT)



Styrenated phenols

Secondary antioxidants, shown in Figure 9, destroy the hydroperoxides before they can decompose into radicals. The alkyl and alkylaryl phosphites are the preferred secondary antioxidants today. They are used only to protect the raw elastomer in storage and during manufacture, since they are destroyed during vulcanization. Combinations of phenols and phosphites are widely used synergistically to protect synthetic rubbers. The dithiocarbamates are no longer generally used as secondary antioxidants because they are very active accelerators. They are used in specific cases, however, such as zinc dibutyldithiocarbamate in butyl rubber production, and nickel dibutyldithiocarbamate for oxidation and static ozone protection in nitrile rubber.

Figure 9. Secondary Antioxidants



Protection against oxidation is not a linear function of antioxidant concentration. Laboratory aging studies will normally indicate an optimum use level, beyond which there is little or no benefit. Amine antioxidants are generally used at 1 to 2 phr and the phenolics at 0.5 to 2 phr.

Antiozonants

Ozone reacts with and cleaves the double bonds of elastomers. Under strain, this causes cracks to form and propagate, leading ultimately to product failure. Elastomers are subject to ozone attack in proportion to their level of unsaturation. Highly unsaturated rubbers (natural, SBR) are readily cracked. Rubbers with low unsaturation (butyl) or a deactivated double bond (neoprene) are moderately ozone resistant. Saturated elastomers (EPDM) are totally resistant.

The requirements for static ozone resistance vs. dynamic ozone resistance are very different, so that choice of antiozonant depends greatly on the expected service of the rubber product. Static protection is provided by petroleum waxes, usually paraffin and/or microcrystalline waxes. The waxes work by blooming to the rubber surface to form a physical barrier to ozone attack. The choice of wax or wax blend is based upon migration temperature where mobility and solubility of the wax in the rubber are balanced so that sufficient bloom occurs for optimum protection. Because the wax film is inextensible, it will rupture under deformation and expose the elastomer. Waxes protect only under static conditions.

The substituted PPDs, described above, are used as chemical antiozonants when service conditions involve continuous dynamic deformation. For a particular rubber, the optimum PPD is one which is soluble in the elastomer, and which will diffuse to the product surface as needed. At the surface, a protective film is formed by the reaction between ozone and the PPD. The ability of the PPD to migrate to the surface as this film is degraded or otherwise broken, and thus react with ozone to repair it, is essential to long term protection. The alkylaryl PPDs are the most widely used for their protection against both oxidation and ozone.

Waxes and PPDs are commonly used together for applications, such as tires, where both static and dynamic protection is required. Waxes are typically used at 1 to 2 phr and PPDs at 1.5 to 3 phr.

When the staining and discoloration of PPDs cannot be tolerated (e.g., white sidewalls) ozone protection is obtained by adding ozone-resistant polymers. These work by relieving stress and inhibitting crack propagation; 30 phr or more of polymer is usually required.

OTHER ADDITIVES

While the foregoing components of a rubber compound determine its primary service characteristics and service life, there are a number of other ingredients used under specific circumstances to modify the processing, appearance, or performance of the rubber product.

Processing Aids – Oils are added during compounding and in some cases are incorporated during elastomer manufacture. They primarily serve a plasticizing function, although at high levels they can also reduce compound cost. Certain elastomers, most notably EPDM and SBR to a lesser extent, can incorporate a relatively large amount of oil into their polymer matrix without significantly affecting the physical properties obtained in the finished rubber product. A very high molecular weight EPDM, for example, that would be nearly impossible to process in a rubber mill will become workable by the incorporation of extender oil during manufacture. Petroleum oils, vegetable oils, and synthetics, such as esters and high molecular weight sulfonic acids, are often added during compounding to reduce elastomer viscosity, promote mold flow and release, improve milling and extrusion, facilitate incorporation of fillers, improve low temperature flexibility, and provide softer vulcanizates.

The petroleum oils are used primarily with nonpolar elastomers and are either naphthenic, paraffinic, or aromatic, depending upon elastomer compatibility, volatility, and expected product service conditions. Vegetable oils are typically from castor or tall oils. Vulcanized vegetable oil products have the unique ability to promote flow under shear but to resist high temperature flow. The synthetic ester plasticizers, such as dioctyl phthalate and dibutyl phthalate are used with polar elastomers.

Although processing aids are used principally to aid processing, some will affect rubber properties to some extent and are utilized for this secondary function as well. For example, a mineral oil plasticizer may also be used to lower modulus, increase resilience, improve elongation, or reduce hysteresis.

Tackifiers – Elastomers with little or no natural tack can be improved by the addition of resins or resin oils (natural abietic acid derivatives), polyindene (coumarone-indene) resins, polyterpene resins and phenol-formaldehyde resins.

Flame Retardants – Most hydrocarbon rubbers will burn, so flame retardants are used if expected service conditions include the possibility of exposure to fire. Fillers such as alumina trihydrate, magnesium hydroxide, and zinc borate are used because they emit inert vapor at high temperatures. Most often, primary flame resistance is suppled by chlorinated paraffins or brominated aromatic resins in combination with antimony trioxide.

Odorants – Small amounts of essential oils are added to rubber compounds to mask characteristic or objectional odors. The most common applications are wearing apparel and drug sundries.

Blowing Agents – For sponge and microporous rubbers, cellular structures are obtained in highly plasticized compounds in either of two ways. Sodium bicarbonate and oleic acid are used to react and liberate carbon dioxide at curing temperatures. Complex azo compounds, which decompose to release nitrogen at curing temperatures, are used to provide a more uniform, closed cell structure than the bicarbonate.

Colors – Non-black products are colored by pigments and organic dyes. White articles usually contain TiO_2, alone or supplemented in whole or part by zinc oxide, zinc sulfide, lithopone (precipitated zinc sulfide/barium sulfate), or talc. A trace of ultramarine blue is sometimes used to correct off-white tints. Iron oxides are used for colors other than white.

Abrasives – Rubber products requiring abrasive properties, such as ink erasers and polishing wheels, use abrasive fillers like ground quartz, pumice, or carborundum.

RUBBER PROCESSING

The production of rubber goods involves two basic operations – compounding and curing. Rubber polymers behave as viscoelastic fluids when sheared at elevated temperatures. This enables the incorporation of the various fillers and chemical additives in the process of compounding.

Mastication

The first step in rubber compounding is mastication or polymer "breakdown". This is essentially development of the polymer's viscoelasticity to make it receptive to the additives. Most synthetic elastomers are produced with the uniformity in chemistry, viscosity and stability that minimizes or precludes the need for mastication. This step is, nevertheless, usually necessary for compounds containing a blend of polymers to provide a uniform mixture prior to further compounding.

Natural rubber is characteristically widely variable in viscosity from lot to lot, so that several lots are usually blended and masticated to control viscosity and physical properties of the compound. The breakdown of natural rubber promotes viscoelasticity by extending or disentangling the polymer chains or by severing the chains. Breakdown cycles for both natural and synthetic rubber are often facilitated by the inclusion of plasticizers.

Polymer breakdown and subsequent compounding was historically accomplished on open roll mills, although today these operations are almost always performed in an internal mixer. The open mill consists of two metal rolls which are jacketed for temperature control. These rolls turn toward each other at fixed separations and often at different speeds. This provides high shear mixing forces. Banbury® Mixers are the most commonly used internal mixers today. They consist of two rotor blades turning toward each other in an enclosed metal cavity. The cavity is fed from a loading chute through which the rubber and in later steps the fillers and compounding chemicals are added. Mixing shear, and consequent mixing time, is determined by rotor shape, size, and speed. A large Banbury can produce 500 kg of finished compound in a matter of minutes.

Masterbatching

As a compounding process, masterbatching means incorporation of the other compounding ingredients into the rubber, except for the curing system. By omitting the cure system, the masterbatch may be intensively mixed without fear that the high temperatures generated will cause premature vulcanization. The objectives of masterbatching are homogeneous blending of polymer and chemical additives, the best possible deagglomeration and dispersion of fillers, and the development of the proper final viscosity. This viscosity, in turn, is a function of the homogeneity achieved in the mixing of the polymer and additives. Because considerable heat is generated during milling, the masterbatch operation must often be terminated before its objectives are attained. This is to avoid heat degradation. In such cases, the compound is remilled before addition of the curing system. Masterbatches are typically prepared in a Banbury mixer, after which they are ejected and cooled.

Separate from the compounding process, masterbatches are often prepared of individual additives that are difficult to disperse during compounding, zinc oxide for example. A concentrated dispersion of the additives in polymer is preformed. This can then be added to the rubber compound for faster incorporation since the additive is predispersed.

Remilling

If the masterbatch shows inadequate dispersion or is too high in viscosity for finish mixing, it is remilled to prepare it for the next step. Remilling is most commonly required with high carbon black, low oil natural rubber tire compounds.

Finish Mixing

The finish mixing step completes the rubber compound by the incorporation of the curing system. This is usually done in an internal mixer where mixing rate and time are balanced to ensure homogeneity without generating temperatures which will cause premature curing. While internal batch mixers like the Banbury are still the standard for rubber compounding, continuous mixers are gaining popularity for their potential to significantly reduce operating costs and to yield exceptionally uniform product quality. Because continuous mixers require continuous accurate weighing and feeding of all components, preparation of ingredients to accomodate these handling requirements is very important. The rubber or masterbatch, for instance, is used in pellet or granular form.

Extruding

Screw-type extruders are used both in the compounding operations and to form articles for vulcanization. In masterbatching, remilling, and finish mixing, the hot batch of rubber generally goes directly to an extruder. The extruder screw will force the rubber through a die to form pellets, or through a pair of rolls to form a slab or sheet. In either case, the extrusion operation allows the compound to cool down while it is turned into a more easily handled form.

Heated mixing extruders can be fitted to batch mixers to improve compound uniformity and reduce viscosity, and they can warm up material for calender feed. Rubber compound as strips or pellets is fed to the extruder where it is heated and extruded in slug or rope form into the nip of a rubber calender. This type of extruder can also be used to take cold finished compound in strip, pellet, or slab form, heat it, blend it, and extrude it in the desired shape. This can be a finished shape, such as a rubber hose, which can be continuously vulcanized right after the extruder. This can also be a component for fabrication with other parts into a more complex item such as a tire. Where the shape must be very precise, the compound may be first warmed on a mill or warm-up extruder and then fed to a shaping extruder.

Calendering

Rubber calenders consist of at least three rolls which can be adjusted for gap, speed and temperature. They are used to form sheeting to required lengths and thickness for subsequent building operations. They are also used for frictioning or skim coating fabrics. Cord and wire are coated in this way for making plies used in the construction of tires and conveyor belts.

Vulcanization

After the rubber compound has been processed and formed, it is vulcanized. This process involves three stages: induction, curing, and reversion or overcure. The induction period is the time at vulcanization temperature during which no measurable crosslinking occurs. It determines the safety margin of the compound against “scorch” during the processing steps preceeding crosslinking. Scorch is premature vulcanization that can occur due to the effects of heat and time. Because these effects are cumulative, the time until scorch will slowly decrease with each processing step. Scorching results in a tough and unworkable batch, which must be scrapped. The time to scorch is dictated by the processing and the additives used, so that a well designed compound will have a scorch time slightly longer than the equivalent of its maximum anticipated cumulative heat history.

The amount of time the compound must be cured, the cure time, is determined in part by the “rate of cure”. This is the rate at which crosslinking and the consequent development of stiffness (modulus) occurs. Cure time is also a function of the desired “state of cure”. As vulcanization (crosslinking) proceeds, the various properties developed by vulcanization are not optimized simultaneously. At any given time during vulcanization, the state of cure is a measure of the development of these properties. Cure time is the time required for the compound to reach a state of cure where the desired balance of properties has been attained.

When a compound is cured beyond the point where its balance of properties has been optimized it becomes overcured. For most elastomers, overcure means the compound becomes harder, weaker and less elastic. With other elastomers, particularly most natural rubber compounds, overcure results in reversion. The compound softens, becoming less elastic and more plastic.

Preparation – Rubber stocks about to be assembled for vulcanization may be in a number of forms, such as calendered strips or sheets, plied up slabs, extruded tubes or partially combined with fabrics by frictioning or skimming operations. Tires, tubes, hose, belts, footwear, rolls and many other articles are built to proximate finished form before vulcanization. The various stocks that are combined to form such articles must be dimensionally stable, free from bloom, and possess the required building tack, all of which depend upon proper compounding and processing. The building tack in SBR and some heavily loaded rubber compounds can be improved to some extent by the use of pine tar, rosin esters and various coal tar or petroleum derivatives. The use of cements or solvents is also practiced in some cases to assure against ply separation or splice failure during cure.

Vulcanization or curing may be accomplished by a number of methods, depending on the compound in process, and the size, shape and overall structure of the finished article.

Press Curing – Press curing includes the molding of articles by compression, transfer, or injection methods. Blocked-in articles which are cured directly between press platens also come under this classification, as well as unblocked slabs. The heat source is generally saturated steam. Electrically heated platens are also used in some installations. Radio frequency waves have been suggested as a means of curing or for pre-heating blanks to reduce the press cure time.

Compounds for press curing must be carefully designed to flow properly without scorching before the desired shape is reached, and to cure rapidly so that a maximum turnover is obtained. They must be easily removed from the molds after cure and exhibit attractive surfaces in the finished form. The flow characteristics depend on the plasticity of the uncured stock as well as selection of the proper acceleration to permit complete filing of the cavity before the cure begins.

Flat Belting and Slab Cures – In articles of this type, the press platens and side strips control the dimensions of the finished article. Belting structures of both transmission and conveyor types are built to their approximate finished shapes before curing. The fabrics they contain have been dried and stretched before frictioning and skim coating, and an additional stretch is applied to each section in the press prior to and during cure.

Slabs for soling, tile, or matting must possess suitable flow characteristics and they must be properly accelerated to permit “cycling” in multistage presses without developing porosity as the pressure is released and reapplied during cure. Slabs for such articles are built to their approximate finished thickness on the calender or sheeting mill, and heel blanks or similar items may be cut by dies from strips taken directly from a warm-up mill.

Open Steam Curing – Open steam curing is used in the production of hose, wire and cable, and other extruded articles such as tubing or channel stripping. With this method, the article may be in direct contact with the steam, wrapped with fabric tape, encased in an extruded covering of lead, or supported by soapstone in a shielded pan. Equipment may consist of a jacketed autoclave or a closed chamber in which the articles are placed and steam is introduced.

Another method of open steam curing is used in the production of insulated wire and cable. This method, known as the CV (continuous vulcanization) process, utilizes jacketed tubes which may be 60 meters (200 feet) in length and operate under internal steam pressure upward of 1.4 MPa (200 psi) as compared to the 200 to 550 kPa (30 to 80 psi) range of the conventional steam vulcanizer.

In operating a closed-chamber steam vulcanizer, the curing cycle consists of a rise to a predetermined pressure, a holding period at the required curing pressure, and a blowdown to atmospheric pressure. In the CV process, extruded wire or cable covering goes directly from a tuber into steam at curing pressure and, with the latest equipment design, passes through a water or condensation seal prior to emerging from the tube at atmospheric pressure.

Dry Heat Curing – Articles such as coated fabrics and footwear may be cured in heated dry air. Coated fabrics are generally festooned in heaters and cured at atmospheric pressure, although by the use of certain dithiocarbamate accelerators, curing in a roll as it comes from the calender can be accomplished at room or slightly elevated temperatures. Footwear heaters are generally operated at 200 kPa (30 psi) air pressure, and ammonia gas is sometimes used to produce a glossy surface on the finished article.

Protection against oxidation is not a linear function of antioxidant concentration. Laboratory aging studies will normally indicate an optimum use level, beyond which there is little or no benefit. Amine antioxidants are generally used at 1 to 2 phr and the phenolics at 0.5 to 2 phr.

Continuous Curing of Extrusions – Direct, continuous curing as the rubber exits the extruder is growing in popularity. In addition to minimizing handling and labor costs, very fast line speeds can be obtained. These factors make for economical extruded articles when a particular item can be run for long periods without changing compounds or profiles (dies).

Hot air can be used to provide the heat for continuous vulcanization. This method gives a clean, attractive surface and has a wide processing latitude to easily make a variety of shapes. The negative aspects are the poor heat transfer of air and the possibility of oxidation during cure. Shearing head extruders can be used to heat the compound to vulcanization temperature before it exits the die, thus overcoming some of the problems with poor heat transfer of air. Fluidized beds improve heat transfer over air alone. High velocity air is pumped upward in the curing trough to fluidize small glass beads (Ballotini). Beads adhering to the extrudate are normally removed by spray or brushed upon exit from the fluidized bed. Complex profiles can make complete removal difficult.

Liquid Cure Medium (LCM) uses a eutectic mixture of salts to heat the extrudate. The molten salt bath usually has a metal conveyor to keep the rubber compound submersed. This method has good heat transfer to the rubber. However, cleaning salt off the extrudate can be difficult and satisfactory disposal of dilute salt rinse is becoming increasingly difficult. This method is advantageous for articles with the low compression set obtained by using peroxides. Sulfur can be used as a coagent to minimize surface tack. Deformation problems versus other atmospheric methods are sometimes minimized.

Microwave with Hot Air Soak is another current method. Particularly effective for thick section extruders, it also retains the clean extrudate surface of the straight hot air method, but with significantly faster heating. Nevertheless, microwave methods put additional constraints on compounding. In a microwave field, heating occurs simultaneously throughout the rubber. Polar rubbers such as neoprene and nitrile will usually heat very rapidly in the microwave unit. Hydrocarbon rubbers heat slower unless they contain 20 to 40 volume percent carbon black. Localized hot spots can develop if the black loading is too high or if dispersion is poor. High zinc oxide levels, to 20 phr, can also improve microwave heating.

PHYSICAL TESTING OF RUBBER

Most testing of rubber and rubber compounds is conducted to determine processing characteristics or to measure physical properties after vulcanization. Processability of a rubber compound is dependent on the compound's viscosity and elasticity. Generally, the physical properties of vulcanized rubber compounds are measured by static and dynamic mechanical tests designed to simulate the mechanical conditions of finished rubber products. Following are the test procedures and instruments most widely used to measure and evaluate processability and finished properties.

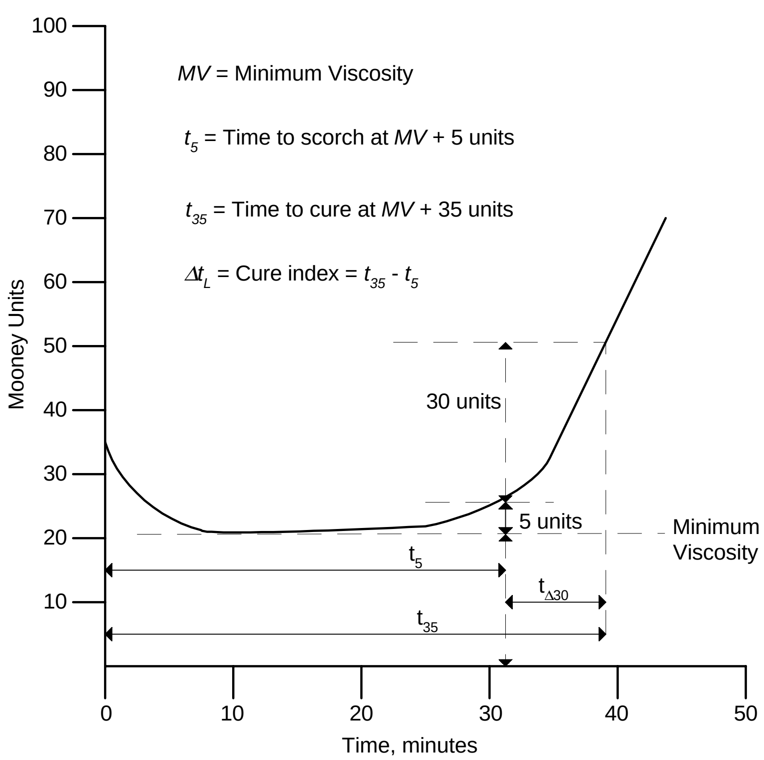
Processability

The fabrication of rubber products generally involve the mixing and processing of unvulcanized compounds through complex equipment. Tests to measure the processability of unvulcanized rubber are chiefly concerned with rheological properties. That is, the response of the rubber compound to the forces and temperatures imposed on it during the operations of mixing, extrusion, calendering, and curing. Generally, these tests are used for control purposes in factory operations to ensure that subsequent processing and curing steps are carried out uniformly.

The earliest and still one of the most popular rheological instruments is the shearing disk viscometer. This is generally referred to as the Mooney Viscometer named after Melvin Mooney (1893–1968) of U.S. Rubber.

Mooney Viscosity, Mooney Scorch, Cure Index – The Mooney Viscometer is widely used throughout the rubber industry as a standard instrument for determining the relative viscosity of rubber and rubber-like materials in the raw or compounded (but uncured) state. It is also used for determining the curing characteristics of vulcanizable compounds. The viscometer measures the force, or torque, required to rotate a metal disk, or rotor, within a shallow cylindrical cavity filled with rubber compound (ASTM D-1646). A typical curve from a Mooney Viscometer test is shown in Figure 10.

Figure 10. Typical Mooney Viscosity Curve



The terms which are used throughout the rubber industry to describe stock flow and cure characteristics are defined on it, and discussed further below. Mooney Viscosity is reported in Mooney units, which are related to the torque required to rotate the disk. The value reported is not a true viscosity, but it does indicate relative viscosity, or resistance to flow, of compounds measured under the same conditions. The test temperature and the running time when the viscosity measurement is taken must be defined when comparing Mooney Viscosity values of different compounds. A common test temperature is 100°C (212°F). The running time should be long enough so that the reported viscosity is the minimum viscosity (MV) on the curve. Four minutes is a common running time. Some rubber processors use different times and temperatures.

Mooney Scorch Time is the total running time to reach a viscosity of five or ten units above the minimum (t_5 or t_{10}). It is used as a rough measure of the processable life of a compound under normal processing conditions – the greater the scorch time, the longer the processable life. A common test temperature for Mooney Scorch measurements is 121^{o}C (250^{o}F), but some processors may use different temperatures because of particular factory experience.

Mooney Cure Time is defined as the total running time to reach a viscosity of 35 units above the minimum (t_{35}). It is used to estimate curing time at the test temperature.

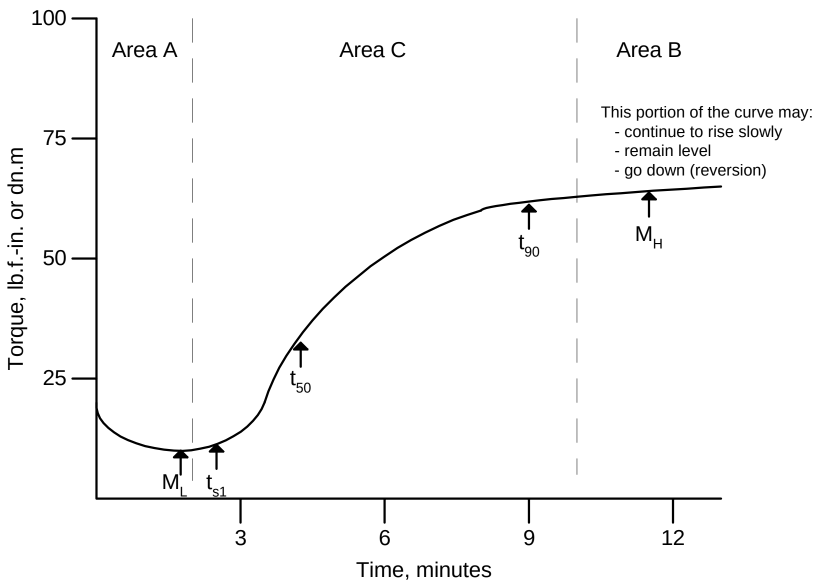
Cure Index, t_L, is the difference between the Cure Time and the Scorch Time (t_{35}-t_5). It is used as a measure of cure rate of the compound – the smaller the Cure Index, the faster the cure rate.

The Mooney Viscometer test is one of the oldest processability tests in the rubber industry. Many processors now prefer the oscillating disk rheometer (ODR) for measuring cure time and cure rate, but the Mooney Viscometer is usually preferred for viscosity and scorch time measurements.

Oscillating Disk Rheometer – The oscillating disk rheometer (ODR) measures the complete curing characteristics of an elastomer compound, from a green (uncured) stock to a fully cured vulcanizate, at a specified temperature (ASTM D-2084). Data from the ODR are often used in conjunction with Mooney viscosity and scorch to characterize the processing and curing behavior of elastomer compounds. Mooney Viscometer measurements are usually made at processing temperatures, while ODR measurements are usually made at curing temperatures.

The ODR measures the force (torque) required to oscillate a biconical rotor back and forth within a shallow cavity filled with rubber compound. As the compound cures, its viscosity increases and more torque is needed to move the rotor. The instrument plots a continuous curve of torque versus time. This curve is often called an ODR trace. From an ODR trace, the rubber compounder can estimate stock viscosity, scorch time, cure rate and cure state. Important test variables are the arc through which the disc oscillates, the speed of oscillation, and the test temperature. The usual arc is 1^o (i.e., 1^o on either side of the starting point, or a total swing of 2^o); some laboratories use 3^o or 5^o. Normal oscillation rate is 100 cycles per minute. Test temperature should be close to the expected cure temperature. A typical ODR trace is shown in Figure 11.

Figure 11. Typical ODR Trace



The measurements which can be made from this trace and the terms used to describe them are:

Area A – This gives an indication of compound viscosity.

Area B – This indicates the rate of cure of the compound.

Area C – This indicates the state of cure of the vulcanizate.

M_L, Minimum torque – A measure of the viscosity of the uncured compound.

M_H, Maximum torque – A measure of cure state. With some compounds, maximum torque can be related to vulcanizate modulus and hardness.

t_{s1} – Time for torque to increase 1 dn.m (0.1N.m) or 1 lbf-in above M_L – a measure of scorch time or processing safety. Some laboratories use t_{s2} (i.e., time for torque to increase 2 dN.m or 2 1lbf-in above ML) instead of t_{s1}.

t_{50}, t_{90} – Time to reach 50% or 90% of maximum torque development, calculated as time to 0.5 M_H or 0.9 M_H – a measure of cure rate or an estimate of cure time at the test temperature. The shorter the time, the faster the cure rate.

Some rubber compounders use other measures of cure rate and cure time which can be derived from the ODR trace. For example:

t'_{50}, t'_{90} – Time for torque to reach $M_L + 0.5 (M_H - M_L)$ or $M_L + 0.9 (M_H - M_L)$.

Cure Rate Index – The slope of the linear portion of the rising curve between t_{s1} and t_{90}.

Vulcanizate Tests

By far the most frequently measured rubber properties are hardness, tensile strength, and elongation. These are often referred to as the physical properties of a vulcanizate. These are supplemented by additional tests designed to be more or less predictive of actual service performance and service life.

Hardness – Hardness, as applied to rubber products, is the relative resistance of the surface to indentation under specified conditions. Hardness of rubber is usually measured with a small spring-loaded hardness gauge known as a durometer (ASTM D-2240). The durometer may be handheld or mounted on a stand. The measurement is made by pressing the indentor against the sample and reading the scale, which is calibrated in arbitrary units ranging from 0 (soft) to 100 (hard). A Type A durometer is used for most soft rubber products; there is also a Type D durometer for hard rubber and plastic-like materials. On the A scale, a gum rubber band would measure around 40, a tire tread 60, and a shoe sole 80.

Hardness is probably the most often-measured property of elastomer vulcanizates. It appears in almost every specification and is widely used by rubber goods manufacturers for quality control. However, its practical significance is questionable, because surface indentation rarely bears any relationship to end-use performance. Also, hardness is a very imprecise measurement; it is not uncommon to find 5 or more points difference in readings by different people on the same piece of rubber. Nevertheless, hardness will probably remain as a standard test in the rubber industry because it is simple and quick to measure and has been correlated with product quality over many years of experience.

Stress-Strain/Tensile Properties – Somewhat more meaningful and useful to the industry are stress-strain data or tensile properties. Stress-strain curves are generated through the pulling (or tensile straining) of a "dumbbell" (ASTM D-412). This dumbbell is died out of a flat cured sheet about 2 mm thick. The stress required to break the dumbbell is the tensile strength. The strain or % stretch registered at the instant of rupture is called ultimate elongation, or simply elongation. It is common practice to record and tabulate the stress values at 100%, 200%, etc. instead of plotting curves.

Tensile properties are normally measured at room temperature (about 23^{o}C). Equipment is available for doing this at lower or higher temperatures, which have a pronounced effect on the hardness and stiffness of a vulcanizate.

Tensile Strength is defined as the force per unit of the original cross-sectional area which is applied at the time of rupture of a test specimen. It is expressed in pounds force per square inch, kilograms force per square centimeter, or megaPascals. Tensile strength is an important characteristic as a tool for compound development, manufacturing control and determination of susceptibility to deterioration by oil, heat, weather, and other environmental factors. It is not necessarily an indication of quality, but is often used as such. It is true that the low range of tensile strength values is indicative of low quality compounds and the high range indicative of high quality. However, in the mid-range (about 1500 to 3000 psi), it is difficult to correlate tensile strength with other mechanical properties.

Ultimate Elongation or Elongation at Break is another property measured in conjunction with tensile strength. Elongation, or strain, is defined as the extension between benchmarks produced by a tensile force applied to a specimen. It is expressed as a percentage of the original distance between the benchmarks. Ultimate elongation is the elongation at the moment of rupture. Like tensile strength, elongation is used as a tool for quality control and determination of resistance to environmental effects. With the exception of rubber bands, rubber products are seldom stretched anywhere near their ultimate elongation in service.

Tensile Stress, more commonly called Modulus is the stress required to produce a certain strain, or elongation. Modulus values can be taken at any elongation off the stress/strain curve. In rubber testing, modulus is usually reported as 100% Modulus, 300% Modulus, or 600% Modulus, meaning the stress at 100%, 300%, or 600% elongation.

Stress-strain properties are normally measured on vulcanizates. The tensile properties of uncured stocks are sometimes used as a measure of green strength – i. e., the strength of the stock for handling before cure.

The most commonly used tensile test shape is the dumbbell. However, a straight strip, a molded o-ring, or a ring die-cut out of a slab may also be used. Since tensile test results are somewhat variable, it is common to test two or three specimens out of each cured slab and average the results.

Tensile test machines vary from simple devices, which simply record the force required to stretch the specimen while the operator measures elongation manually, to complex instruments which plot out the entire stress-strain curve or automatically calculate and print out the key tensile properties. Basically, the specimen is clamped between two grips, then one grip moves away from the other at a controlled rate of speed, stretching the specimen until it breaks. The standard strain rate (rate at which the grips are separated) for rubber is 8.5 millimeters per second, or 20 inches per minute.

Heat Resistance – The phrase "heat resistance" as used in the rubber industry really means resistance to irreversible changes in properties as a result of prolonged exposure to high temperature. A rubber vulcanizate heated to high temperature can undergo two different kinds of temporary or reversible change: expansion, and softening (plastic flow). A rubber vulcanizate aged at high temperature can undergo irreversible chemical changes: further crosslinking, cleavage of polymer chains by oxidation, or loss of some ingredients by evaporation or migration. Comparisons of heat resistance generally deal with the chemical stability of the vulcanized polymer in terms of crosslinking and oxidation. The current commercial elastomers differ greatly in inherent heat resistance.

The normal means of measuring heat resistance is to determine stress-strain properties before and after heat aging. Interpretation of results is done in various ways, depending on what the compounder or end user feels is most relevant. Heat resistance is expressed in several ways:

– Percent change in elongation caused by heat aging.
– Percent change in tensile strength caused by heat aging.
– Points change in hardness caused by heat aging.
– Percent of original elongation retained through heat aging.
– Time of aging in hours until breaking elongation drops to 100%.

In an elastomer which hardens during heat aging, loss of rubber-like flexibility is equated with reduction in elongation to 100%.

Compression Set – Compression Set is defined as the residual deformation of a material after removal of an applied compressive stress. Resistance to compression set is the ability of an elastomeric material to recover to its original thickness after having been compressed for an extended period.

For optimum performance in service, compression set values should be as low as possible. Low set values mean that the material has recovered nearly to its original height, and there is very little residual deformation. This is particularly important in applications where a rubber part is expected to provide a seal under a compressive force, and the sealing force is removed and reapplied repeatedly.

Compression set tests may be run either by applying a known constant force to the test specimen (Method A of ASTM D-395) or by compressing the specimen to a known constant deflection (Method B of ASTM D-395). The specimen is held in the compressed position for a specified period of time at a specified temperature, after which the compressive force is removed and the specimen is allowed to recover at room temperature for 30 minutes. In Method A, compression set is the difference between the original and final thickness of specimen, expressed as a percentage of the original thickness. In Method B, compression set is calculated by expressing the difference between the original and final thickness of the specimen as a percentage of the deflection to which the specimen was subjected. The standard specimen for a compression set test is a round pellet. O-rings of specified dimensions can also be tested.

Compression set tests are usually run at elevated temperatures, to simulate conditions or aging effects. Common test conditions are 70 hours at 70°C (158°F) or 100°C (212°F), although heat-resistant materials such as fluoroelastomers may be tested for longer periods of time at temperatures up to 200°C (392°F) or more. If the end product is expected to perform at low temperatures, e.g. below 0°C (32°F), compression set is measured at the expected service temperature.

Although there are differences of opinion about its validity, the compression set test is the easiest to run and therefore the most popular method of measuring the ability of a compound to return to its original shape and dimensions after being deformed for a long time. Low compression set data do not necessarily correlate with high resilience or low creep.

Abrasion Resistance – Abrasion Resistance is defined as the resistance of a rubber composition to wearing away by contact with a moving abrasive surface. It is usually reported as an Abrasion Resistance Index, which is a ratio of the abrasion resistance of the test compound compared to that of a reference standard measured under the same test conditions.

Abrasion resistance is measured under definite conditions of load, speed and type of abrasive surface. The standard laboratory tests generally cannot be used to predict service life, because factors affecting abrasion are complex and vary greatly from application to application. Nevertheless, abrasion resistance tests are useful in making quality control checks on rubber products intended for rough service.

The most frequently used abrasion tester is the National Bureau of Standards (NBS) Abrader. Test samples are pressed under a specified load against a rotating drum covered with abrasive paper. The number of revolutions of the drum required to wear away a specified thickeness of the test specimen is recorded and compared to the number of revolutions required to wear away the same thickness of standard reference material (ASTM D-1630).

The Pico Abrader is used for measuring abrasion resistance of soft vulcanized rubber compounds and other elastomeric materials. A pair of tungsten carbide knives of specified geometry and controlled sharpness are rubbed over the surface of a pellet-shaped sample in a rotary fashion under controlled conditions of load, speed and time. The volume loss of the test material is measured and compared to a reference compound (ASTM D-2228).

The Taber Abrader measures wear by weight and/or thickness loss. Specified abrasive wheels are held under load of 500 or 1000 grams against a test specimen mounted on a rotating turntable. The equipment is described in ASTM D-1044, but the complete method is not followed for elastomer evaluations.

Tear Strength or Tear Resistance – Tear Strength or Tear Resistance of rubber is defined as the maximum force required to tear a test specimen in a direction normal to (perpendicular to) the direction of the stress. Tear strength is expressed as force per unit of specimen thickness – pounds force per inch (lbf/in), kilograms force per centimeter (kgf/cm), or kiloNewtons per meter (kN/m).

There are several types of tear specimens, with no apparent correlation between types. Some are cut (nicked) to provide a starting point for tearing, while others are not. The most frequently used sample is an unnicked 90 degree angle specimen listed in ASTM D-624 as Die C and sometimes referred to as Graves Tear. Other specimens used are a razor-nicked crescent specimen – Die A of ASTM D-624, also referred to as Winkleman Tear – and a trouser tear specimen, so called because it resembles a pair of men's trousers, of ASTM D-470.

Tear test specimens are pulled on a tensile tester at a cross-head rate of 8.5 millimeters per second (20 inches per minute). The maximum force required to initiate or propagate tear is recorded as force per unit thickness. Tear strength is frequently used to indicate relative toughness of different compounds. However, it is difficult to correlate with end-use performance.

Resilience – Resilience is the energy returned by a vulcanized elastomer when it is suddenly released from a state of strain or deformation. High resilience is what causes the bounce or snap often associated with products of natural rubber. In more specific terms, resilience is defined as the ratio of energy given up on recovery from deformation to the energy required to produce the deformation, and is usually expressed as percent. Elastomers are used in many applications because of their resilience properties. High or low resilience may be required, depending on the application. The lower the resilience, the less vibration transmitted. Low resilience is required in dampeners, while high resilience is needed in tires for fuel economy (low rolling resistance).

One instrument used to measure resilience is a vertical rebound tester. In this test, a metal plunger is allowed to fall on the test specimen and the height to which the plunger rebounds is recorded (ASTM D-2632). Another instrument used to measure resilience is the Yerzley Oscillograph. Besides resilience, this instrument can be used to measure other mechanical properties such as static and dynamic modulus, kinetic energy and creep (ASTM D-945). Specimens are loaded by an unbalanced lever, and the resultant cyclic reflections are recorded on a chart. Testing can be done over a temperature range of -40^{o}C to +121^{o}C (-40^{o}F to +250^{o}F).

Hardness Change – Durometer hardness is sometimes used to follow changes in stiffness at low temperatures. This is a simple technique, and may be useful as a check on factory operations, but it is not very precise.

Impact Strength or Impact Resistance – Impact strength or Impact Resistance is the resistance of a material to fracture under a sudden impact, or shock force. It is a measure of the toughness of the material.

Impact strength is usually only determined for plastics and hard elastomer compounds (i.e., those in the D durometer hardness range), where the impact resistance of the material in actual service is important. Soft elastomer compounds will bend, not break, on impact unless they have been cooled below their brittleness temperature. Several types of impact testers and test methods are available. Basically, they all measure the energy required to break a test specimen in a single sharp blow, and can be performed over a temperature range from -70 to +120^{o}C (-94 to +248^{o}F). The most widely used tests are Izod Impact and Charpy Impact; both procedures are given in ASTM D-256.

In the Izod Impact Test, a rectangular specimen is clamped securely at one end, then struck by a weight at the end of a pendulum. As the pendulum continues its swing, it moves a pointer which records the amount of force used up in breaking the specimen. Impact strength is reported as force per unit of specimen width (e.g., N/m or 1bf/in). The specimen is usually notched in the center, but unnotched specimens can also be tested.

The Charpy Impact Test is similar to the Izod test, except that the specimen is supported on both ends like a simple beam. The striking force swings on a pendulum. Impact strength is reported as force per unit width.

Flex Resistance – The term flex resistance does not mean resistance to flexing or resistance to bending. It means the ability to withstand numerous flexing cycles without damage or deterioration. Flex-crack resistance is the ability to sustain numerous flexing cycles without the occurrence of cracks in the surface from stress and ozone attack. Flex-cut-growth resistance is the ability to withstand numerous flexing cycles with a cut in the stressed surface with little or no growth of that cut.

The most common type of failure or damage resulting from repeated flexing is the formation of surface cracks, known as flex cracking. Shoe soles and tires are examples of rubber products that may show flex cracking. Another mode of failure due to flexing is the separation of rubber from fabric in a fabric-supported product such as a conveyor belt.

The two most commonly used flex resistance tests are the DeMattia Flex Test (ASTM D-813) and the Ross Flex Test (ASTM D-1052). The Demattia flexer alternately pushes the test specimen together, bending it in the middle, then pulls it back to straighten it. The Ross flexer repeatedly bends the specimen over a metal rod, then straightens it. In both tests, a small cut or nick of prescribed size and shape may be made in the center of the test specimen. Data generated from these tests include: flex life, the number of test cycles a specimen can withstand before it reaches a specified state of failure; and crack growth rate, the rate at which the cut propagates itself as the sample is flexed. These tests are particularly useful in evaluating compositions that are intended for use in products which will undergo repeated flexing or bending in service.

Another, more elaborate, test is the Monsanto Fatigue to Failure Tester. This instrument measures the ultimate fatigue life as cycles to failure. Tensile-like samples are flexed or stretched at 100 cycles per minute at a preselected extension ratio. Samples can be extended over a range of 10% to 120%. The fatigue performance of compounds can be measured and compared either at constant extension ratio (strain) or at constant strain energies (work input). This instrument is more likely to be used as a research and development tool than as a factory control tester.

Heat Buildup and Compression Fatigue – Heat buildup in elastomers is the accumulation of thermal energy and resultant temperature increase in a rubber product due to internal friction when the product is subjected to repeated, rapid cyclic deformation. The loss in properties of an elastomer due to heat buildup and other molecular effects of dynamic deformation is known as fatigue. Elastomeric compositions which show the least heat buildup and the least change in properties due to fatigue are usually considered the best candidates for use in dynamic applications, such as tires.

The Goodrich Flexometer is used for heat buildup testing (ASTM D-623). A cylindrical test specimen is alternately compressed and then released in rapid cycles for a specified period of time. The temperature rise within the test specimen is recorded. Additional data obtained are permanent set and static compression. The Goodrich Flexometer Test is sometimes called the Compression Fatigue Test, because the test specimen is fatigued, or weakened, by the rapidly cycling compression stress.

Weather and Ozone Resistance Tests

Weathering is a complex combination of erosion and UV light-induced oxidation. No elastomer is immune to this, especially if it is highly filled and light in color. Ozone attack, on the other hand, happens only to stressed vulcanizates of unsaturated polymers when ozone is present in the atmosphere. Saturated elastomers, like EPDM, are virtually immune to ozone attack.

Tests for weather and ozone resistance depend on visual observation of specimens (e.g., for the appearance or growth of checks or cracks), and are therefore somewhat inaccurate and qualitative. The differences are typically so gross, nevertheless, that they can be demonstrated dramatically. A given ozone-containing atmosphere can cause visible attack on one vulcanizate in a few minutes and no attack on another in a week.

Outdoor Exposure – Elastomer compositions progressively degrade in physical properties upon prolonged exposure to the elements (air, sunlight, rain, etc.) because of chemical changes in the elastomer molecule. These changes are accelerated by oxidation from ozone and oxygen in the atmosphere, by ultraviolet rays, by temperature variations, and other environmental factors, but would occur to some extent simply with the passage of time. Typical effects are surface hardening, crazing and cracking, plus gradual changes in tensile strength, elongation, and other physical properties. Some elastomers become soft and gummy, others become hard and inflexible.

In order to determine the actual effects of normal weathering, specimens are exposed outdoors in different locations with different climates. Changes in color, cracking, crazing, chalking, mildew growth, and stress-strain properties are recorded at various time intervals. Typical check periods are 1, 2, 5, 10, and 20 years exposure. Test specimens are usually stretched at low strains and mounted on wooden supporting racks for outdoor exposure. Three procedures are specified by ASTM D-518:

Procedure A – Straight strips elongated 20%.
Procedure B – Bent loops, where the elongation varies from 0 to 25% at different points on the loop.
Procedure C – Tapered samples elongated to strains of 10 to 20%.

The specimens in their supporting racks are usually exposed facing South for maximum sunlight at an angle of 45^o. Samples may also be buried in the ground to determine resistance to moisture, soil chemicals, insects, bacteria and oxidation effects in the absence of direct sunlight.

Weather-Ometer and Fade-Ometer – The Weather-Ometer is a special machine in which test specimens are continuously or intermittently exposed to water spray and artificial light. The light, produced by a carbon arc, is essentially the same wavelenghts as natural sunlight, but with increased intensity in the ultraviolet range. In the Fade-Ometer, specimens are exposed to constant controlled humidity (instead of water spray), along with artificial light. Specimens may be exposed unstrained or under a slight elongation. Both tests are described in ASTM D-570.

As in the other accelerated aging tests, tensile properties are measured after aging and compared with original properties. In addition, visual observations are made for cracking, crazing or color changes, as is done with specimens aged outdoors. The light intensity in the Weather-Ometer and Fade-Ometer can be related to sunlight intensity at various locations throughout the world.

Deterioration by Ozone – Ozone is a highly reactive gas which can cause rubber products to crack and fail prematurely unless they are protected by antiozonants or made of an ozone-resistant elastomer. Ozone is present in the atmosphere, and is produced constantly by arcing in high voltage electrical devices.

To test for resistance to ozone attack, samples are stretched to 20 or 40% strain on a test rack, or bent in a loop to produce a surface strain. The specimens are then placed in the ozone chamber, a special oven equipped with an ozone generator. Ozone concentration in the chamber can be controlled at any desired level – usual test concentrations are 0.5, 1, 3, or 100 ppm (parts ozone per million parts of air by volume). Test temperature is usually 40^oC (104^oF). The test specimens are inspected at various time intervals until initial cracking occurs. Testing may continue until the specimen actually breaks, or may be stopped at some predetermined degree of attack.

Dynamic testing provides a more rigorous test for ozone attack. Here, a special fabric-backed specimen is continuously flexed over a roller within the ozone chamber. Any protective chemical films which might build up on the surface of the specimen in static testing are quickly broken by the continuous flexing. Interpretation of results is the same as for static testing. ASTM D-1149 covers static testing and ASTM D-3395 covers dynamic testing in a controlled ozone atmosphere.

Accelerated Aging

Rubber technologists usually can't, or don't want to, wait five, ten or twenty years to find out how well their compounds will withstand the ravages of weather and time. Therefore, a variety of laboratory accelerated aging tests have been developed to predict the service life and aging characteristics of elastomers and rubber-like materials. These accelerated tests generally do not give exact correlations with service performance, but they do enable screening and comparison of compounds within a practical time scale. And, some useful correlations have been made with long term outdoor aging studies. Some of the more common accelerated aging tests are:

Air Oven – Specimens are exposed to the deteriorating influence of air in an oven at specified elevated temperatures for known periods of time, after which their physical properties are determined (ASTM D573). These are compared with the properties determined on original (unaged) specimens. Changes in hardness and percentage changes in tensile strength and elongation at break are reported.

Heating in Air in a Test Tube – In this method (ASTM D-865), the test specimens are heated in air, but they are confined within individual test tubes. The isolation provided by the test tube prevents cross-contamination of compounds due to loss of volatile materials (e.g., antioxidants or curatives) and their subsequent migration into other rubber specimens being tested. With this test, characteristics may be determined in a way that is free of some of the complications inherent in community-type aging devices where numerous compounds are aged in the same enclosure. Here again, hardness and tensile properties measured after aging are compared with original properties and the percent change is calculated.

Deterioration by Heat and Oxygen – In this test (ASTM D-572), pure oxygen under pressure is used to accelerate oxidative deterioration of the rubber specimen. Test specimens are placed in a metal vessel designed to retain an internal atmosphere of pure oxygen gas under pressure up to 2070 kPa (300 psi) at temperatures of 70^{o} or 80^{o}C (158^{o} or 176^{o}F). After the prescribed aging period, hardness and tensile properties are measured and compared with original properties. Usually, hardness change and percent change in tensile strength and elongation are reported.

Fluid Resistance

No elastomer can withstand and contain every fluid known to industry. Stated in another way, any elastomer can be severely attacked and rendered unserviceable by a selected fluid or liquid. Measurement of fluid resistance requires definition of terms. One elastomer is better than another only with reference to one class of chemically similar fluids, like aromatic oils, ketones, oxidizing acids, or brake fluid.

Fluid Resistance (Chemical Resistance) – Fluid resistance is a general term describing the extent to which a rubber product retains its original physical characteristics and ability to function when it is exposed to oil, chemicals, water, organic fluids or any liquid which it is likely to encounter in actual service. Fluid resistance tests may not give a direct correlation with service performance, because service conditions cannot easily be defined or controlled. However, they yield comparative data on which to base judgements about expected performance, and they serve as useful tools for screening compounds for particular service conditions.

Determining fluid resistance involves measuring a specimen's weight, volume and physical properties before and after exposure to the selected fluids for a specified time at a specified temperature. The effect of the fluid on the specimen is judged on the basis of the percent of the original properties retained or lost. Properties most often checked are volume change, weight change, and changes in hardness, tensile strength and elongation at break. Changes in tear strength, compression set, and low temperature properties are also frequently evaluated.

ASTM D-471 describes the testing of rubber in contact with fluids. It also lists the composition of various fluds which have been given special ASTM designations and are used as reference standards throughout the rubber industry.

ASTM Oils are specific petroleum-base oils which have different aniline points covering the range of commercial lubricating oils. The aniline point of a petroleum oil appears to correlate with the swelling action of that oil on an elastomer. In general, the lower the aniline point, the more severe the swelling action.

ASTM Reference Fuels have been selected to provide the maximum and minimum swelling effects produced by commercial gasolines. Reference Fuel A has a mild effect on elastomeric vulcanizates and produces results of the same order as highly paraffinic, straight run gasolines. Reference Fuel B causes more severe swelling, exceeding the swelling action of commercial gasoline. Reference Fuel C causes even more severe swelling, and is typical of the highy aromatic premium grades of automotive gasoline.

ASTM Service Fluids are special fluids which are either non-petroleum or are compounded from special petroleum hydrocarbon fractions. They have swelling characteristics outside the range of ASTM Oils or Reference Fluels.

Oil Resistance – Oil resistance is a special case of fluid resistance. Broadly defined, oil resistance is the ability of a rubber product to perform its intended function while in contact with oil. This recognizes that the elastomer may be swollen or weakened to some extent by the oil.

The tire rubbers (natural rubber, SBR), when placed in oil, absorb the fluid slowly until either the oil is all gone or the rubber has disintegrated. They never reach equilibrium. The so-called oil-resistant elastomers absorb some oil, especially at elevated temperature, but only a limited amount. With some it may be negligible. Most end uses requiring oil-resistant elastomers can tolerate appreciable swelling or volume increase. Hence, volume increase is not a very significant way to measure the ability of a rubber article to perform its intended function in oil.

Low-Temperature Properties

As elastomer compositions are cooled below room temperature, they stiffen and become more difficult to bend, twist, or stretch. This stiffening is gradual until the stiffening temperature (also called the second order transition temperature) is reached. Then, further decrease in temperature causes a very sharp increase in stiffness. At very low temperatures, the elastomer composition becomes brittle and will crack or break if subjected to sudden impact or bending; the temperature at which this occurs is known as the brittle point or brittleness temperature.

The brittle point has no relationship to stiffness as shown by stiffness vs. temperature curves. For example, stiffness measurements may indicate a high degree of flexibility at a certain temperature, but impact tests may show the composition to be brittle at the same or higher temperature. This lack of relationship is not surprising, however, because stiffness measurements involve loading at low speed and low deflection, while brittleness tests involve loading at high speed and high deflection.

Following are some of the tests used to determine flexibility behavior of elastomer compositions at low temperatures. Results can be used to predict actual field performance.

Brittleness Temperature – This test (ASTM D-746) is used to determine the temperature at which the composition exhibits brittle failure. A small rectangular strip is clamped in a holder at one end and cooled to a predetermined temperature in a chilled liquid bath. The specimen is then given a sudden sharp blow by a solenoid-actuated striking arm. If the specimen does not fracture, the temperature of the liquid bath is lowered and the process is repeated until the specimen breaks when struck.

Torsional Stiffness – Torsional stiffness tests measure the modulus of rigidity of an elastomer composition over a broad temperature range. Two widely-used tests are ASTM D-1043, which uses the Clash-Berg Tester, and the ASTM D-1053, which uses the Gehman Torsional Stiffness Tester. In both tests, the sample is chilled to a preset temperature, then twisted with a known force. The amount of twist is measured and related to the stiffness (modulus of rigidity) of the sample. The test temperature is then changed and the test is repeated, until a complete curve of stiffness vs. temperature is plotted. The temperature which produces a stiffness of 69 MPa (10000 psi) is sometimes taken as the Stiffness Temperature.

Temperature Retraction – This test (ASTM D-1329) can be used to measure viscoelastic properties of elastomers and rubber-like materials at low temperatures, and also to evaluate crystallization effects. The test specimen is stretched to a specified elongation and frozen at -70^{o}C (-94^{o}F). Then, it is gradually warmed until it begins to retract toward its unstretched dimensions. The temperature at which the specimen retracts 10% has been found to correlate with brittleness temperature.

This article was adapted from “RUBBER” by Peter A. Ciullo and Norman Hewitt in
Industrial Minerals and Their Uses, Peter A. Ciullo (Ed.), Noyes Publications, 1996

BIBLIOGRAPHY

Ohm, R.F., 1990, *The Vanderbilt Rubber Handbook*, R.T. Vanderbilt Co., Norwalk, CT

Morton, M., 1987, *Rubber Technology*, Van Nostrand-Reinhold, New York

Morton, M., 1959, *Introduction to Rubber Technology*, Reinhold, New York

Bateman, L., 1963, *The Chemistry and Physics of Rubber-Like Substances*, Wiley, New York

Dick, J.S., 1987, *Compounding Materials for the Polymer Industries*, Noyes, Park Ridge, NJ

Stephens, H.L., 1985, *Textbook for Intermediate Correspondence Course*, American Chemical Society, Rubber Division, Washington, DC

Katz, H.S., Milewski, J.V., 1987, *Handbook of Fillers for Plastics*, Van Nostrand-Reinhold, New York

Hagemeyer, R.W., 1984. *Pigments for Paper*, TAPPI Press, Atlanta

Eirich, F.R., 1978, *Science and Technology of Rubber*, Academic Press, New York

Mark, H.F., et al, 1971, *Encyclopedia of Polymer Science and Technology*, Interscience, New York

—THE FORMULARY—

I.

NATURAL RUBBER
POLYISOPRENE

TIRE CARCASS COMPOUND
Uniroyal

	1	2	3	4
BLE®	----	1.0	----	0.5
Naugard® Q	----	----	1.0	0.5
Natural Rubber	60.0	60.0	60.0	60.0
Cis BR	20.0	20.0	20.0	20.0
SBR	20.0	20.0	20.0	20.0
N-660 Black	50.0	50.0	50.0	50.0
Naphthenic Oil	15.0	15.0	15.0	15.0
Zinc Oxide	3.0	3.0	3.0	3.0
Stearic Acid	1.0	1.0	1.0	1.0
Tackifying Resin	2.0	2.0	2.0	2.0
Bonding Agent R-6	2.0	2.0	2.0	2.0
Bonding Agent M3P	1.0	1.0	1.0	1.0
MBTS	1.0	1.0	1.0	1.0
DPG	0.25	0.25	0.25	0.25
Insoluble Sulfur, 80% Oiled	3.0	3.0	3.0	3.0
Mooney Viscosity				
ML(1+4) @100°C	49	48	49	50
Mooney Scorch, MS@132°C				
3 pt. Rise, minutes	11.9	11.6	11.6	11.4
Physical Properties at Room Temperature				
Press Cured 10 minutes @176°C				
Tensile Strength, MPa	19.6	21.0	20.2	19.5
Elongation, %	500	510	480	500
300% Modulus, MPa	9.5	9.2	9.5	9.5
Hardness, Shore A	57	58	57	56
Tear, Die C, kN/m	46.5	55.0	49.7	53.0
Oven Aging, 2 Weeks @ 70°C, % Retention				
Tensile Strength	61	72	78	77
Elongation	54	63	71	67
300% Modulus	----	146	137	138
Hardness, points change	+5	+5	+6	+6
DeMattia Flexing - Unaged				
Kilocycles (kc) to failure	133	688	405	527
Flex to Fatigue Failure (100%)				
kc to failure				
Unaged	79	257	139	215
Aged 70 hours @ 100°C	12.7	28.7	23.0	29.1

TIRE BLACK SIDEWALL COMPOUND
Uniroyal

	1	2	3	4	5
Flexzone® 7P	----	2.0	2.5	3.0	4.0
Sunproof® Improved Wax	----	4.0	3.0	1.5	1.0
Natural Rubber	55.0	55.0	55.0	55.0	55.0
Cis BR	45.0	45.0	45.0	45.0	45.0
N-660 Black	30.0	30.0	30.0	30.0	30.0
N-375 Black	20.0	20.0	20.0	20.0	20.0
Naphthenic Oil	7.0	7.0	7.0	7.0	7.0
Zinc Oxide	3.0	3.0	3.0	3.0	3.0
Stearic Acid	1.5	1.5	1.5	1.5	1.5
Delac® NS	1.0	1.0	1.0	1.0	1.0
Insoluble Sulfur, 80% Oiled	2.0	2.0	2.0	2.0	2.0
Mooney Viscosity					
ML (1+4) @ 100°C	49	45	46	48	48
Mooney Scorch, MS @132°C					
3 pt. Rise, minutes	21.0	22.7	21.5	19.2	19.0
Physical Properties at Room Temperature					
Press Cured 10 minutes @160°C					
Tensile Strength, MPa	19.2	19.9	18.9	19.3	19.0
Elongation, %	540	580	560	550	540
300% Modulus, MPa	8.6	8.3	8.2	8.6	8.7
Hardness, Shore A	52	51	52	52	52
Oven Aging, 2 Weeks @ 70°C, % Retention					
Tensile Strength	67	82	91	95	96
Elongation	62	76	81	82	82
300% Modulus	150	130	130	130	130
Hardness, points change	+8	+8	+8	+7	+7
Tear, Die C	75	83	90	95	100
Static Ozone Flexing, Bent Loop (hours), 50 pphm, 40°C					
OK		4	4	4	4
VVS		6	6	6	6
VS				96	72
C	6				
Dynamic Ozone Flexing, 25% Extension, 50 pphm, 40°C					
Hours to Crack	8	24	24	72	144
Outdoor Dynamic Flexing*					
KC to failure		16951			39560

*Naugatuck, CT – Continuous Flexing – Aged 6 months prior to testing

TIRE COVER STRIP COMPOUND

Uniroyal

	1	2
Naugawhite® Antioxidant	----	2.0
Sunproof® Improved Wax	1.0	1.0
Natural Rubber	45.0	45.0
Chlorobutyl Rubber	25.0	25.0
Royalene® 505	30.0	30.0
N-660 Black	35.0	35.0
Naphthenic Oil	10.0	10.0
Zinc Oxide	5.0	5.0
Stearic Acid	2.0	2.0
Vultac® 5	0.5	0.5
Delac® NS	0.7	0.7
Insoluble Sulfur, 80% Oiled	2.0	2.0
Mooney Viscosity		
ML (1+4) @ 100°C	37	35
Mooney Scorch, MS @ 132°C		
3 pt. Rise, minutes	13.2	13.7
Physical Properties at Room Temperature		
Press Cured 10 minutes @ 160°C		
Tensile Strength, MPa	15.7	15.9
Elongation, %	540	560
300% Modulus, MPa	6.7	6.5
Hardness, Shore A	52	51
Tear, Die C, kN/m	26.3	29.8
Oven Aging, 2 Weeks @ 70°C, % Retention		
Tensile Strength	88	96
Elongation	72	85
300% Modulus	140	130
Hardness, points change	+5	+5
Tear, Die C	89	92
Dynamic Ozone Belt, 50 pphm, 300 hours	No cracks	No cracks

TIRE CHAFER/RIM FLANGE COMPOUND
Uniroyal

	1	2
Flexzone® 7P	----	3.0
Natural Rubber	50.0	50.0
SBR	50.0	50.0
N-326 Black	75.0	75.0
Naphthenic Oil	20.0	20.0
Zinc Oxide	5.0	5.0
Stearic Acid	2.0	2.0
SP 6700 Resin	5.0	5.0
Sunproof® Improved Wax	1.0	1.0
Bonding Agent M3P	0.8	0.8
Delac® NS	1.5	1.5
Insoluble Sulfur, 80% Oiled	3.0	3.0
Mooney Viscosity		
ML (1+4) @ 100°C	52	53
Mooney Scorch, MS @ 132°C		
3 pt. Rise, minutes	15.5	14.7
Physical Properties at Room Temperature		
Press Cured 10 minutes @ 160°C		
Tensile Strength, MPa	19.5	18.7
Elongation, %	410	420
300% Modulus, MPa	13.8	12.9
Hardness, Shore A	83	81
Tear, Die C, kN/m	63	68
Oven Aging, 2 Weeks @ 70°C, % Retention		
Tensile Strength	71	89
Elongation	63	70
Hardness, points change	+9	+8
Tear, Die C	72	89
Pico Abrasion Index	91	89
Bent Loop, 50 pphm Ozone, 40°C, (Condition)		
1008 Hours	C	VS
Dynamic Ozone Belt, 50 pphm Ozone, 30°C, (Hours)		
OK		
VVS		72
VS		
S		
C	24	

TIRE BEAD FILLER/APEX COMPOUND

Uniroyal

Naugard® Q	----	2.0	----
Novazone® AS	----	----	2.0
Natural Rubber	100.0	100.0	100.0
Phenol Formaldehyde Resin	10.0	10.0	10.0
N-351 Black	55.0	55.0	55.0
Aromatic Oil	5.0	5.0	5.0
Zinc Oxide	10.0	10.0	10.0
Stearic Acid	2.0	2.0	2.0
SP 6700 Resin	2.0	2.0	2.0
Bonding Agent M3P	2.0	2.0	2.0
Delac® NS	0.6	0.6	0.6
Benzyl Tuex®	0.25	0.25	0.25
CPT (vulcanization inhibitor)	0.25	0.25	0.25
Insoluble Sulfur, 80% Oiled	5.0	5.0	5.0
Mooney Viscosity			
ML (1+4) @ 100°C	49	51	52
Mooney Scorch, MS @ 132°C			
3 pt Rise, minutes	15.9	16.3	15.1
Physical Properties at Room Temperature			
Press Cured 10 minutes @ 177°C			
Tensile Strength, MPa	15.7	16.2	17.7
Elongation, %	370	350	450
200% Modulus, MPa	8.1	8.3	9.7
300% Modulus, MPa	13.1	13.7	13.4
Hardness, Shore A	84	85	87
Tear, Die C, kN/m	39	40	37
Oven Aging, 2 Days @ 100°C, % Retention			
Tensile Strength	49	59	74
Elongation	26	31	27
Hardness, points change	+6	+5	+1
Tear, Die C	52	61	62
Oven Aging, 2 Weeks @ 70°C, % Retention			
Tensile Strength	61	73	77
Elongation	31	40	33
Hardness, points change	+5	+5	+1
Tear, Die C	59	65	71
DeMattia Flexing - Unaged			
Kilocycles (kc) to failure	8	12	84

TIRE BELT SKIM COMPOUND
Uniroyal

	1	2	3	4
Natural Rubber	100.0	100.0	100.0	100.0
Black N-330	55.0	55.0	55.0	55.0
Zinc Oxide	7.0	7.0	7.0	7.0
Stearic Acid	1.0	1.0	1.0	1.0
Naphthenic Oil	6.0	6.0	6.0	6.0
Cobalt Naphthenate	1.0	1.0	1.0	1.0
Bonding Agent R-6	2.5	2.5	2.5	2.5
Flexzone® 7P(6PPD)	----	1.0	2.0	3.0
HMMM	2.0	2.0	2.0	2.0
DCBS	0.7	0.7	0.7	0.7
80% Insoluble Sulfur	5.0	5.0	5.0	5.0
Mooney Viscosity				
ML (1+4) @ 100°C(212°F)	55	53	52	52
Mooney Scorch				
MS @ 132°C(270°F)				
3 pt. Rise, minutes	11.5	12.0	11.0	11.0
Curemeter @ 160°C(320°F)				
ts2, minutes	2.6	2.6	2.6	2.5
tc90, minutes	9.5	9.4	9.1	9.1
ML, dNm	0.6	0.6	0.6	0.6
MH, dNm	5.2	5.1	5.1	5.1
Physical Properties				
Press Cured 16 minutes @ 160°C(320°F)				
Tensile @ RT, MPa(psi)	21.4	21.5	21.7	21.5
	(3104)	(3118)	(3147)	(3118)
Elongation, %	360	370	380	380
300% Modulus, MPa(psi)	15.6	14.9	14.8	14.5
	(2262)	(2161)	(2146)	(2103)
Hardness, Shore A	74	72	70	70
Tear, Die C, kN/m(lb-in.)	63.0	61.0	64.0	62.0
	(360)	(348)	(365)	(354)

TIRE BELT SKIM COMPOUND
Continued

	1	**2**	**3**	**4**
Aged 2 Weeks @ 70°C(158°F)				
Tensile @ RT, MPa(psi)	17.0	19.1	21.0	20.5
	(2466)	(2770)	(3046)	(2973)
Elongation, %	200	260	280	280
300% Modulus, MPa(psi)	17.0	15.1	14.4	14.8
	(2466)	(2190)	(2088)	(2146)
Hardness, Shore A	85	84	82	82
Tear, Die C, kN/m(lb-in.)	19.0	32.0	35.0	36.0
	(166)	(183)	(200)	(206)
Dynamic Flexing				
Flex Fatigue to Failure				
Unaged (KC)	23.0	64.0	110.0	109.0
Aged 24 Hours @ 100°C(212°F)				
(KC)	0.5	12.5	39.0	40.0
Tel Tak at Room Temperature				
Unaged	28	25	31	19
Aged 3 Days @ 40°C(104°F)	15	8	7	5

TIRE BASE TREAD
Uniroyal

	1	2	3
Natural Rubber	60.0	60.0	60.0
Cis BR 40.0	40.0	40.0	40.0
N-660 Black	45.0	45.0	45.0
Zinc Oxide	5.0	5.0	5.0
Stearic Acid	1.5	1.5	1.5
Naphthenic Oil	6.0	6.0	6.0
Hydrocarbon Resin	2.0	2.0	2.0
Naugard® Q (TMQ)	----	1.0	2.0
Delac® NS (TBBS)	1.0	1.0	1.0
DTDM	1.0	1.0	1.0
80% Oiled Insoluble Sulfur	3.25	3.25	3.25
Mooney Viscosity			
ML (1+4) @ 100°C(212°F)	52	51	51
Mooney Scorch			
MS @ 132°C(270°F)			
3 pt. Rise Time	21.0	22.5	23.0
Physical Properties at Room Temperature			
Press Cured 10 minutes @ 176°C(270°F)			
Tensile, MPa (psi)	14.9	15.4	15.6
	(2161)	(2233)	(2262)
Elongaton, %	350	370	380
300% Modulus, MPa(psi)	12.0	11.1	11.0
	(1740)	(1610)	(1595)
Shore A Hardness	56	55	55
Tear, Die C, kN/m(lb-in.)	32.1	30.3	31.0
	(183)	(173)	(177)
Physical Properties at Room Temperature			
Aged 2 Weeks @ 70°C(158°F) - % Retention			
Tensile Strength	51.5	69.0	71.0
Elongation	35.0	59.1	60.0
Tear, Die C	78.0	80.5	82.0
Tel-Tak @ Room Temperature			
Unaged	43	33	28
Aged 3 Days @ 40°C(104°F)	27	18	12

TIRE BASE TREAD
Continued

	1	2	3
Rheovibron Measurements and Dynamic Flexing			
Frequency, Hz	11/110	11/110	11/110
Tangent Delta			
@ Room Temperature	0.07/0.11	0.08/0.11	0.09/0.11
@ 50°C(122°F)	0.06/0.08	0.07/0.09	0.07/0.09
@ 75°C(167°F)	0.05/0.07	0.05/0.07	0.06/0.07
Flex Fatigue to Failure (100%)			
Unaged (KC)	120	165	180
Aged 3 Days @ 100°C(212°F)	10	31	29

AGRICULTURAL SEMI-PNEUMATIC TIRE

Goodyear

Natsyn 2200	100.00
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay 100	2.00
Flexzone 3-C	4.00
Blended Wax	2.00
N-330 Carbon Black	35.00
N-550 Carbon Black	25.00
Pine Tar	5.00
Naphthenic Oil	2.00
Amax	1.20
Unads	0.20
Sulfur	2.00
Total	**183.40**
Rheometer, 150°C, T'C90	
Minutes	6.6
Original Physical Properties	
Tensile, psi	3300
Elongation, %	500
300% Modulus, psi	1900
Hardness, Shore A	62
Tear, Die C	360
Compression Set (B)	
22 Hrs. @ 70°C, %	11.9

MOTOR MOUNT
Goodyear

Natsyn 2200	100.00
Zinc Oxide	5.00
Stearic Acid	2.00
Wingstay 100	1.50
Agerite Resin D	1.00
Sunolite 240 Wax	2.00
MT (N-990) Black	35.00
Naphtenic Oil	2.50
Morfax	2.25
Methyl Tuads	0.25
Sulfur	1.00
Total	**152.50**
Rheometer, 287°F, T'C90	
Minutes	25.0
Original Physical Properties	
Tensile, psi	3100
Elongation, %	575
300% Modulus, psi	550
Hardness, Shore A	52
Goodyear Healy Rebound	
Room Temperature, %	90.0
212°F, %	93.2

WIPER BLADE
Goodyear

Natsyn 2200	70.00
EPDM	30.00
Zinc Oxide	7.50
Stearic Acid	2.00
Wingstay 29	1.25
N-550 Carbon Black	50.00
Naphthenic Oil	10.00
Durax	1.20
Methyl Tuads	0.25
Sulfur	1.50
Total	**173.70**
Rheometer, 160°C, T'C90	
Minutes	4.2
Original Physical Properties	
Shore A Hardness	64
Tensile, psi	1900
Elongation, %	450
200% Modulus, psi	600
300% Modulus, psi	1100
Tear Strength-Die C, ppi	185
Compression Set (B), 22 Hrs. @ 70°C, %	20.5

PIPE GASKET
Goodyear

	55 Shore A	65 Shore A
Natsyn 2200	100.00	100.00
Zinc Oxide	5.00	5.00
Stearic Acid	2.00	2.00
Wingstay 29	1.00	1.00
Wingstay 100	1.50	1.50
N-330 Carbon Black	----	30.00
N-770 Carbon Black	40.00	30.00
Naphthenic Oil	20.00	20.00
Durax	1.50	1.50
Methyl Tuads	1.25	1.25
Sulfasan R	1.20	1.20
Sulfur	0.40	0.40
Total	**173.85**	**193.85**
Rheometer, 155 °C, T'C90		
Minutes	8.8	7.3
Original Properties		
Shore A Hardness	53	64
Tensile, psi	3000	2750
300% Modulus, psi	825	1500
Elongation, %	540	445
Compression Set (B)		
22 Hrs. @ 70°C, %	7.4	7.8
Weight Change		
480 Hrs. @ 100°C in water, %	3.0	4.0

PIPE GASKET
Goodyear

Natsyn 2200	60.00
Plioflex 1713 CX5	59.97
Zinc Oxide	5.00
Stearic Acid	2.00
Wingstay 29	1.00
Wingstay 100	1.50
Sunolite 240 Wax	2.00
N-770 Carbon Black	40.00
Hard Clay	60.00
Naphthenic Oil	20.00
Santocure	1.50
Methyl Tuads	0.50
Sulfasan R	1.20
Sulfur	0.50
Total	**255.17**
Rheometer, 155°C, T'C90	
Minutes	12.0
Original Physical Properties	
Shore A Hardness	51
Tensile, psi	2100
Elongation, %	625
300% Modulus, psi	5500

POLYISOPRENE SEAL
R.T. Vanderbilt

Natsyn 2200	100.0
Zinc Oxide	5.0
Stearic Acid	2.5
SAF Black (N-110)	45.0
THERMAX (N-990)	20.0
AGERITE RESIN D	3.0
Spider Sulfur	1.25
ALTAX	1.5
METHYL TUADS	0.25
Total	168.0
Physical Properties	
Tensile, MPa (psi)	21.6(3140)
100% Modulus, MPa (psi)	29(420)
Elongation, %	460
Hardness, Shore A	70

FOOTWEAR FOXING OR TOE CAP COMPOUND
Goodyear

Natsyn 2200	100.00
Whiting	100.00
Titanium Dioxide	15.00
Ultramarine Blue	0.01
Zinc Oxide	5.00
Light Process Oil	3.50
Stearic Acid	1.00
Wingstay L	0.50
Durax	1.00
BIK	1.00
Sulfur	2.00
Total	**229.01**
Cure, 300°F	11.0
Original Physical Properties	
Tensile, psi	2350
Elongation, %	640
300% Modulus psi	250
Hardness, Shore A	52
Specific Gravity	1.43
Gardner Color	
RD	78.15
A	-0.6
B	7.1

EXTRUSION COMPOUNDS

R.T. Vanderbilt

ASTM D2000	AA515	AA725
SMR-5	100.0	100.0
Stearic Acid	0.5	0.5
Zinc Oxide	5.0	5.0
AGERITE STALITE S	2.0	2.0
VANFRE AP-2	2.0	2.0
VANPLAST R	5.0	5.0
Circo Light Oil	8.0	---
Neophax a	30.0	15.0
FEF Black (N-550)	30.0	80.0
McNAMEE CLAY	40.0	---
Sulfur	2.75	2.75
AMAX	1.0	1.0
METHYL TUADS	0.2	0.2
Total	226.45	213.45
Cured 10 minutes at 153°C(307°F)		
300% Modulus, MPa (psi)	5.4(780)	16.6(2400)
Tensile Strength, MPa (psi)	13.8(2000)	18.8(2730)
Elongation, %	570	370
Hardness, Shore A	50	68
Tear Die A, kN/m(pli)	21.1(120)	28.2(160)
Cured 5 minutes at 160°C(320°F)		
300% Modulus, MPa (psi)	5.4(790)	16.1(2340)
Tensile Strength, MPa (psi)	14.5(211)	18.7(2720)
Elongation, %	530	380
Hardness, Shore A	50	67
Tear Die A, kN/m(pli)	56.3(320)	33.4(190)
Mooney at 121°C(250°F)		
Scorch, t5, minutes	10	9
Plasticity, ML	15	28
Compression Set after 22 hours at 70°C(158°F)		
% Set	38	22

CONVEYOR BELT COVER
R.T. Vanderbilt

Natural Rubber, Grade 5	80.0
BUDENE 1207 Polybutadiene	20.0
VANPLAST R	2.0
Sundex 790	12.0
Stearic Acid	1.0
Zinc Oxide	3.0
VANOX 6H	1.1
VANWAX H	2.5
ISAF Black (N-220)	50.0
AMAX	1.5
VANAX NS	1.5
Sulfur	2.5
METHYL TUADS	0.2
Total	175.8
Density, Mg/m^3	1.11
Properties, Cured 20 minutes at 157°C(315°F)	
300% Modulus, MPa (psi)	11.7(1700)
Tensile Strength, MPa (psi)	24.2(3500)
Elongation, %	550
Hardness, Shore A	60
Mooney at 121°C(250°F)	
Scorch, t5, minutes	18
Plasticity, ML	60

BRIDGE BEARING PAD
R.T. Vanderbilt

Natsyn 2200	100.0
Zinc Oxide	3.0
Stearic Acid	2.0
Wingstay 100-AZ	1.0
VANOX 3C	2.0
VANWAX H	2.0
HAF (N-330) Carbon Black	50.0
Aromatic Oil	10.0
Sulfur	0.5
MORFAX	1.9
Total	172.4
Properties, Cured 17 minutes @ 143°C	
Hardness, Shore A	62
Tensile, MPa (psi)	26(3750)
Elongation, %	650
Density, Mg/m^3	1.10
Tear Strength, Die C, kN/m (pli)	68(390)
Compression Set after 22 Hours @ 70°C(158°F)	
Method B, % Set	13

BLOWOUT PREVENTER
Goodyear

Natsyn 2200	70.00
Zinc Oxide	5.00
Stearic Acid	2.00
Wingstay 29	0.50
Wingstay 100	0.75
Sunolite 240	1.00
N-339 Carbon Black	35.00
N-550 Carbon Black	25.00
High Aromatic Oil	5.00
Amax	1.00
Unads	0.25
Sulfur	1.20
Total	**176.70**
Rheometer, 142°C, T'C90	
Minutes	26
Original Physical Properties	
Shore A Hardness	70
Tensile, psi	3600
Elongation, %	500
300% Modulus, psi	2000
Tear Strength-Die C, ppi	490
Compression Set (B), 22 Hrs. @ 70°C, %	20

PHARMACEUTICAL BOTTLE STOPPER

Goodyear

Natsyn 2200	100.00
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay S	1.00
Cumar Resin	5.00
Hard Clay	75.00
Amax	1.50
DOTG	0.50
Sulfur	2.00
Total	**190.00**
Rheometer, 160°C, T'C90	
Minutes	8.2
Original Physical Properties	
Shore A Hardness	55
Tensile, psi	3000
Elongation, %	600
300% Modulus, psi	620
500% Modulus, psi	1900
Compression Set (B)	
22 Hrs. @ 70°C, %	32.0
Volume Change	
Water, 72 Hrs. @ 70°C, %	0.5

RUBBER BAND
Goodyear

Natsyn 2200	100.00
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay 29	1.00
Calcium Carbonate	10.00
Amax	1.00
Methyl Tuads	0.40
Sulfur	1.50
Total	**118.90**
Rheometer, 163°C, T'C90	
Minutes	6.0
Original Physical Properties	
Shore A Hardness	45
Tensile, psi	3100
Elongation, %	700
500% Modulus, psi	600

RUBBER SPRING
Goodyear

Natsyn 2200	100.00
Zinc Oxide	5.00
Stearic Acid	2.00
Wingstay 29	1.00
Wingstay 100	1.25
Microcrystalline Wax	1.50
N-990 Carbon Black	15.00
Naphthenic Oil	8.00
Morfax	2.00
Methyl Tuads	0.25
Sulfur	1.00
Total	**137.00**
Rheometer, 150°C, T'C90	
Minutes	15.5
Original Physical Properties	
Shore A Hardness	45
Tensile, psi	3400
Elongation, %	650
300% Modulus, psi	300
500% Modulus, psi	1050
Resilience (20°C), %	93
Compression Set (B), 22 Hrs. @ 70°C, %	14.5

RACQUET BALL
Goodyear

Natsyn 2200	100.00
Pliolite S6B	2.50
Stearic Acid	1.50
Wingstay 29	0.75
Agerite Resin D	0.75
Hi-Sil	25.00
Triethanolamine	0.50
Zinc Oxide	3.00
Durax	1.50
BIK	0.25
Sulfur	3.25
Total	**139.00**
Rheometer, 160°C, T'C90	
Minutes	3.4
Original Physical Properties	
Shore A Hardness	68
Tensile, psi	1975
Elongation, %	450
300% Modulus, psi	900
Tear Strength-Die C, ppi	200
Resilience, %	
(20°C)	80
(100°C)	90

RUBBER THREAD

Goodyear

Natsyn 2205	100.00
Zinc Oxide Triethanolamine	3.00
Stearic Acid	2.00
Wingstay S	1.00
Altax	1.00
Methyl Tuads	3.50
Total	**110.50**
Rheometer, 165°C, T'C90	
Minutes	10
Original Physical Properties	
Shore A Hardness	35
Tensile, psi	2700
Elongation, %	750
300% Modulus, psi	200
500% Modulus, psi	400

TRANSLUCENT ARTICLE
R.T. Vanderbilt

Natsyn 2200	100.0
OCTOATE Z	2.0
WINGSTAY L-HLS	0.5
VANFRE M	0.5
Sulfur	1.5
VANAX NS	0.7
ZETAX	0.4
Total	105.6
Properties, Cured 7 minutes @ 155°C	
Hardness, Shore A	35
Tensile, MPa (psi)	21(3100)
Elongation, %	850
Density, Mg/m^3	0.92

HIGH RESILIENCE COMPOUND

R.T. Vanderbilt

Natsyn 2200	100.0
THERMAX N-990 Carbon Black	40.0
Flexon 845 Naphthenic Oil	2.5
Zinc Oxide	5.0
Stearic Acid	2.0
WINGSTAY 100	1.25
WINGSTAY 29	1.0
Sulfur	1.0
MORFAX	2.0
METHYL TUADS	0.25
Total	137.0
Properties, Cured 16 minutes @ 150°C	
Hardness, Shore A	52
Tensile, MPa (psi)	23(3400)
Elongation, %	650
Density, Mg/m^3	1.01
Resilience at 20°C, %	93
Resilience at 100°C	~95

DUROMETER 40 COMPOUND FOR TEAR STRENGTH
PPG

SMR 5L		65.0
EPDM 535*		35.0
Ciptane 255LD*		18.0
N330		20.0
Naphthenic Oil		25.0
Stearic Acid		0.5
Zinc Oxide		3.5
Sulfur		0.9
MDB		1.3
TMTD		0.2
*Masterbatch 3' to 150°C		
Specific Gravity		1.06
Cure Rate ODR 150°C, T90 minutes		9
Mooney Scorch 130°C, T5 minutes		12
Viscosity, ML100		64
Cure 150°C: 15'/25'	Original	Aged 350 hrs. 70C
Durometer	41	46
M300, MPa	2.6	
Tensile	10.2	7.7
Elongation, %	674	535
MG Trouser Tear, kN/m		12
PICO Abrasion Index		26
Monsanto Fatigue, 100%		31 kc

DUROMETER 45 COMPOUND FOR MOTOR MOUNT
PPG

SMR CV60		50.0
SBR 715		50.0
Silica or Black		30.0
Silane A189		0.7
Paraffinic Oil		20.0
TMQ		2.0
ZMTI		2.0
Stearic Acid		2.0
Zinc Oxide		8.0
Sulfur		0.5
MDB		2.0
TBBS		2.0
OTOS		0.5
PEG 3350		1.0
Total		170.7
Filler	Hi-Sil 532EP	GPF N660 Black*
Cure Rate 155C, T90.	13	19
Mooney Scorch 121C, T5	24	30+
Viscosity, ML100	22	24
Durometer	43	44
M20, Mpa	0.40	0.39
M300	5.4	4.1
Tensile	18	20
Elongation, %	570	700
Aged 700 hours at 125C		
M20, Mpa	0.55	0.68
Tensile	4.1	4.5
Elongation, %	145	120
Percent Retained	25	17
Compression Set, 70 hours 100C, %	40.7	46.7
Goodrich Flexometer, 100C; 22.5%, 1 Mpa, %		
Static Compression	18	21
Dynamic Compression	31	34
Drift	-12	-13
Permanent Set	1.3	2.7
Heat Build-Up, °C	7	10

*A189 & OTOS OMITTED

DUROMETER 55, OZONE RESISTANCE, HANDLE GRIP
PPG

	Banbury 1
Natural Rubber	60.0
EPDM 55	20.0
SBR 1502	20.0
Hi-Sil 243LD	25.0
Hard Clay	20.0
Naphthenic Oil	15.0
Stearic Acid	2.0
LWM Polyethylene	5.0
MC Wax	2.0
Phenolic AO35	4.0
	Banbury 2
Zinc Oxide	5.0
Sulfur, Insoluble	2.5
TBBS	2.0
ZBDC	0.5
Total	183.0
Specific Gravity	1.11
Cure Rate 150°C, T90	16 minutes
Mooney Scorch 130°C, T5	30+ minutes
Viscosity, ML100	26
Stress-Strain, Cure: 20’/150°C	
Durometer	55
M20, MPa (psi)	0.62(90)
M300	3.9(570)
Tensile	13.4(1950)
Elongation	590%
MG Trouser Tear, kN/m (ppi)	4.6(26.5)
Abrasion Indices	
PICO	31(72 mg)
NBS	67(250 Rev.)
Pendulum Rebound (Z)	59.2%
Ozone Resistance: 50 PPHM, 40°C, 20%	
3 Days	No Cracking; Gloss Unchanged

DUROMETER 60 COMPOUND FOR LOW COST
PPG

	Banbury 1
SIR 20	100.0
Hard Clay	50.0
Hi-Sil 210	20.0
Silene 732D	20.0
Aromatic 100°C Resin	15.0
ODPA	1.0
TMQ	0.5
MC Wax	1.5
	Banbury 2
PEG 3350	2.0
Zinc Oxide	5.0
Sulfur	3.0
TBBS	2.0
Total	220.0
Specific Gravity	1.28
Cure Rate 150°C, T90	11 minutes
Mooney Scorch 130°C, T5	25 minutes
Viscosity, ML100	36
Cure: 20'/150°C	
Durometer:	61
M20, MPa (psi)	1.1(165)
M300	9.5(1375)
Tensile	20.5(3000)
Elongation	540%
MG Trouser Tear, kN/m (PPI)	8.7(50)
Cure: 30'/150°C	
Pendulum Rebound (Z), %	
At 23°C/100°C	55.4/70.8
PICO Abrasion Index	80
Compression Set, 3D 100°C	77.1%
Goodrich Flexometer: 100°C: 22.5%; 1 MPa	
Static Compression	15%
Dynamic Compression	6.3%
Drift	9.7%
Set	16.0%
Heat Build-Up	20°C

DUROMETER 60, HEAT RESISTANCE & TEAR STRENGTH
PPG

SMR CV60			100.0
Hi-Sil 190G			40.0
100C CI Resin			5.0
Stearic Acid			1.0
ODPA			1.5
ZMTI			1.5
PEG 3350			1.0
Zinc Oxide			3.0
Sulfur			2.8
TBBS			3.0
Specific Gravity			1.10
Cure Rate 150°C, T90 minutes			3.6
Mooney Scorch 130°C, T5 minutes			7.0
Viscosity, ML100			77
Cure: 5’/150C	Original	Aged 170 hrs./100C	Aged 700 hrs/85C
Durometer	59	72	72
M300, MPa	6.8	---	---
Tensile	36	23	29
Elongation, %	720	540	625
MG Trouser Tear, kN/m			22
PICO Abrasion Index			90(103 vs. NR)
Compression Set, 70 hrs./100C			84%
Pendulum Rebound (Z): at 23°C			57%
at 100°C			69%
Goodrich Flexometer: 100C; 22.5%; 1 MPa			
Permanent Set			17%
Heat Build-Up			26°C

DUROMETER 60, TEAR STRENGTH, LOW HEAT BUILD-UP
PPG

		Banbury 1
NR		100.0
Hi-Sil 233T		48.0
TMQ		1.0
HPPD		2.0
Process Aid MS40		3.0
PEG 3350		1.0
Zinc Oxide		4.0
		Banbury 2
Sulfur		1.0
MBS (MOR)		2.0
MDB (MORFAX)		1.0
TBTD		0.3
Total		165.3
Specific Gravity		1.13
Cure Rate 138°C, T90		16.0 minutes
Mooney Scorch 130°C; T5		13.0 minutes
Viscosity, ML 100		75
Cure: 20'/138°C	Original	Aged 7 Days/100°C
Durometer	62	77
M300, MPa(PSI)	5.3(765)	---
Tensile	32(4600)	21(3070)
Elongation	715%	445%
MG Trouser Tear	At 23°C	At 100°C
KN/m	22	27
Lbs./Inch	125	155
Dynamic Properties Cure: 30'/138°C		
Pendulum Rebound, %		
At 23°C		70.1
At 100°C		79.3
Monsanto Fatigue, 100%		32 kilocycles
DeMattia 23°C: 500% Cut Growth		20 kilocycles

DUROMETER 60, TEAR STRENGTH, LOW HEAT BUILD-UP Continued

Goodrich Flexometer 90°C; 25%; 1.6 MPa	
Static Compression	25%
Dynamic Compression	16%
Set	20%
Heat Build-Up	55°C
DMA; 1 Hz, 20% Strain	
E’ @ 30°C, MPa	14.9
E’ @ 90°C	11.3
E” @ 0°C	2.5
Tan Delta @ 80°C	0.118
PICO Abrasion Index	77

DUROMETER 64, LOW ROLLING RESISTANCE TRUCK TREAD

PPG

		Banbury 1
NR-SMR 5		70.0
BR 1203		30.0
N299 Black		46.0
Hi-Sil 243LD		18.0
Silane SI 69		0.5
Aromatic Oil		15.0
Zinc Oxide		5.0
Stearic Acid		1.0
HPPD		1.0
TMQ		1.0
MC Wax		2.0
		Banbury 2
Sulfur		1.4
TBBS		1.75
Total		192.65
Specific Gravity		1.10
Cure Rate 150°C, T90		13.1 minutes
Mooney Scorch 130°C, T5		21 minutes
Viscosity, ML100		48
Cure: 18’/150°C		
Durometer		
M100, MPa (PSI)		2.4(350)
M300		11.6(1680)
Tensile		24.3(3600)
Elongation		530%
MG Trouser Tear, kN/m (PPI)		8.3(47)
Cure: 23’/150°C	At 23°C	At 100°C
Pendulum Rebound, (Z)%	52.8	67.2
Durometer	64	61
Goodrich Flexometer: 100°C, 22.5%; 1 MPa		
Permanent Set		7.6%
Heat Build-Up		24°C

DUROMETER 64, LOW ROLLING RESISTANCE TRUCK TREAD Continued

Dynamic Mechanical Properties 1 Hz		
	DMA (E)	RDA (G)
Strain	15% Flexural	5% Shear
E'/G' 0°C	17.1	3.42
30°C	11.7	2.60
60°C	8.2	2.15
E"/G" 0°C	3.76	0.82
30°C	2.22	0.49
60°C	1.45	0.32
Tan Delta 0°C	.220	.239
30°C	.190	.190
60°C	.176	.158
PICO Abrasion Index		141
DeMattia Cut Growth, 500%		105 KC

DUROMETER 65 COMPOUND FOR BRASS ADHESION

PPG

		Banbury 1
SMR 5		100.0
Hi-Sil 210		15.0
HAF N326		50.0
HPPD		2.0
Naphthenic Oil		5.0
Stearic Acid		2.0
Zinc Oxide		6.0
R-F Resin		3.0
		Banbury 2
Sulfur		4.0
TBBS		1.2
HMMM 65%		1.5
Total		189.7
Specific Gravity		1.12
Cure Rate 160°C, T90		6.0 minutes
Mooney Scorch 130°C, T5		9.5 minutes
Viscosity, ML 100		52
Cure: 11’/160°C		
Durometer		66
M300, MPa(PSI)		13.5(1970)
Tensile		24.0(3500)
Elongation		505%
Adhesion to Brass Coated Wire (6 X .35 + 3 X .20)		
Static Pull-Out:	Lbs./Inch	% Cover
Original	230	90
Green Humid Aged 3 Days 50°C	235	100
Humid Aged 5 days 90°C	170	60
Disc Fatigue 70°C: 4 Hours*	Separations	Pull-Out, Lbs./In.
Green Humid Aged	0	245
Humid Aged	0	220
*All-Black Control with Cobalt:		
Green Humid Aged	2	150
Humid Aged	6	95

DUROMETER 65 COMPOUND FOR LOW HEAT BUILD-UP
PPG

		Banbury 1
NR		85.0
BR 1220		13.0
Silane A189		1.8
Hi-Sil 532EP		65.0
TiO2		3.0
Phenolic Antioxidant		1.0
TMQ		0.5
MC Wax		1.0
Tackifier		2.0
Aromatic Resin 100°C		3.0
		Banbury 2
PEG		0.5
ZnO		3.0
Insoluble Sulfur 80%		1.3
MBS		1.0
DTDM		1.5
Total		184.6
Specific Gravity		1.17
Cure Rate 145°C, T90		11 minutes
Mooney Scorch 130°Cm T5		13 minutes
Viscosity, ML 100		56
Cure: 15’/145°C		
Durometer		66
M300 PSI (MPa)		2700(14.3)
Tensile		3700(25.3)
Elongation, %		505
MG Trouser Tear, PPI (kN/m)		35(6.1)
Pendulum Rebound (G-H):		
At 23°C		71%
At 100°C		82%
PICO Abrasion Index		82
Goodrich Flexometer:		
A. 100°C; 22.5%; 1 MPa		
B. 98°C; 25%; 1.6 MPa		
	A	B
Permanent Set, %	3.5	9.8
Heat Build-Up, °C	20	38

DUROMETER 65 COMPOUND FOR THICK ARTICLES

PPG

SMR CV60		100.0
Hi-Sil 190G		30.0
Ciptane I		20.0
100C Resin		5.0
Tall Oil D30		2.0
ODPA		1.0
Stearic Acid		2.0
PEG 3350		1.0
Zinc Oxide		5.0
Sulfur		3.0
TBBS		3.0
Specific Gravity		1.13
Cure Rate MDR 138C: T50 minutes		13
Cure Rate MDR 138C: T90 minutes		19
Mooney Scorch 121C, T5 minutes		30
Mooney Viscosity, ML100		45
Cure at 138C, minutes	30	120
Durometer	65	69
M300, Mpa	7.3	8.2
Tensile	34	30
Elongation, %	695	620
Aged 170 hours at 80C		
Durometer	70	72
Tensile, Mpa	31	27
Elongation, %	585	525
MG Trouser Tear, kN/m	15	15
PICO Abrasion Index	87	81
Compression Set, 70 hrs.100C, %	79	60
Pendulum Rebound (Z),%: 23C	58	54
100C	71	70
DeMattia Cut Growth, 500%, KC	15	9

DUROMETER 65 COMPOUND FOR THICK ARTICLES Continued

Goodrich Flexometer, 100C; 22.5%;1 Mpa, %		
Dynamic Compression	5.0	8.7
Drift	10	3.3
Permanent Set	13	7.4
Heat Build-Up, °C	25	18

DMA, 1 Hz, 20% Strain	30C	60C	30C	60C
E’	11	8.0	14	10
E”	1.26	0.83	1.30	0.88

DUROMETER 70 COMPOUND FOR EXERCISE BAND

PPG

SMR CV60	70.0
EPDM 55	30.0
Hi-Sil 532EP	25.0
Ciptane 255LD	30.0
Titanium Dioxide	5.0
100C Resin	5.0
Paraffinic Oil	5.0
Stearic Acid	1.0
ODPA	1.0
Zinc Oxide	3.0
Sulfur	2.5
TBBS	3.0
Specific Gravity	1.11
Cure Rate, MDR 160C, T90 minutes	2.8
Mooney Scorch 130C, T5 minutes	11
Viscosity, ML100	84
Cure: 10’/160C	
Durometer at 23C	69
at 100C	63
Pendulum Rebound (Z), % at 23C	53
at 100C	60
Stress/Strain:	
M20, MPa	1.2
M100	2.3
M300	6.0
Tensile	15
Elongation, %	570
MG Trouser Tear, kN/m	11.9

DUROMETER 75 COMPOUND FOR BUSHINGS
PPG

IR 2200		100.0
Ciptane I		55.0
Tall Oil D30		3.0
Naphthenic Oil		3.0
Titanium Dioxide		3.0
ZMTI		1.0
ODPA		1.0
Zinc Oxide		3.0
Stearic Acid		2.0
PEG 3350		1.0
Sulfur		3.0
TBBS		3.0
TMTM		0.3
Specific Gravity		1.14
Cure rate, MDR 155C, T50 minutes		2.9
Mooney Scorch 121C, T5 minutes		21
Mooney Viscosity, ML 100		40
Durometer at 23C		74
at 100C		71
Stress/Strain	Original	Aged 700 hrs. 80C
Durometer	74	84
M300, MPa	11	
Tensile	27	14
Elongation, %	555	270
MG Trouser Tear, kN/m		8.6
PICO Abrasion Index		88
Compression Set, 70 hrs. 100C		62
Pendulum Rebound (Z), %, at 23C		52
at 100C		63
Dynamic Modulus DMA: 30C; 1 Hz; 18%		
E”, MPa		1.7
E’		21
Tangent Delta		0.082
Goodrich Flexometer: 100C; 22.5%; 1 MPa		
Permanent Set, %		7.0
Heat Build-Up		19°C
DeMattia Cut Growth, kc to 500%		9

DUROMETER 77 COMPOUND FOR REVERSION RESISTANCE

PPG

SMR CV60			100.0
Hi-Sil 210			50.0
100C Resin			5.0
ODPA			1.0
Stearic Acid			2.0
PEG 3350			1.0
Zinc Oxide			5.0
Sulfur			3.0
TBBS			3.0
Specific Gravity			1.16
Cure Rate 150C, T90 minutes			14
Mooney Scorch 130C, T5 minutes			30+
Mooney Viscosity, ML100			80
Cure 150C, min.:20/30	Original	Aged 700 hrs. 85C	Aged 170 hrs. 100C
Durometer	77	82	80
M300, Mpa	7.1		
Tensile	27	19	10
Elongation, %	660	410	230
MG Trouser Tear, kN/m			11
PICO Abrasion Index			74
Compression Set, 70 hrs. 100C			78%
Pendulum Rebound (Z), % 23C			56
100C			66
Goodrich Flexometer: 100C; 22.5%; 1 MPa			
Permanent Set, %			14
Heat Build-Up, °C			30
DeMattia Cut Growth, 500%			8 kilocycles
Dynamic Modulus, DMA: 1 Hz; 20% Strain; 60C	E’	E”	Tan Delta
	21 MPa	1.5 MPa	0.070

DUROMETER 80 COMPOUND FOR SOLING
PPG

SMR CV60		50.0
BR 1220		35.0
SBR 1205		15.0
Hi-Sil 233S		55.0
Naphthenic Oil		3.0
MC Wax		1.0
Phenolic A.O.		0.3
Sulfur		2.0
MBTS		2.0
Zinc Oxide		1.0
HMT		2.0
Specific Gravity		1.14
Cure Rate, MDR 155C, TS2 minutes		2.0
T90 minutes		3.0
Reversion, 20 minutes		0
Mooney Scorch, 121C, T5 minutes		12
Remilled		14
Viscosity, ML100		125
Cure: 12’/155C	Original	Aged 170 hours 110C
Durometer	79	
M300, Mpa	5.4	
Tensile	21	5.7
Elongation, %	725	90
MG Trouser Tear, kN/m		21.6
PICO Abrasion Index		87
Compression Set, 70 hrs. 100C, %		89
DeMattia Cut Growth, 500%, Kilocycles		8
Pendulum Rebound (Z), % at 23C		52
at 100C		60
Goodrich Flexometer, 100C; 22.5%; 1 MPa		
Permanent Set, %		23
Heat Build-Up		39°C

DUROMETER 80 COMPOUND FOR SOLING
Continued

Dynamic Modulus, DMA 1 Hz, 15% Strain:	0°C	30°C	60°C
E’, Mpa	42	32	24
E’	4.8	4.5	3.1
Tangent delta	.114	.142	.132

DUROMETER 80 COMPOUND FOR FIBER REINFORCED
PPG

		Banbury 1
NR		70.0
SBR 1502		30.0
Hi-Sil 210		20.0
HAF N330		30.0
TMQ		1.0
Rayon Floc		20.0
Aromatic Resin 100°C		5.0
Stearic Acid		3.0
Zinc Oxide		10.0
R-F Resin		3.0
		Banbury 2
HMMM (65%)		4.0
Sulfur		2.0
TBBS		2.0
ZBDC		0.1
Total		200.1
Specific Gravity		1.13
Cure Rate 150°C, ODR T90		14 minutes
Mooney Scorch, 121°C, T5		21 minutes
Viscosity, ML100		42
Cure: 25'/150°C	With Grain	Cross Grain
Durometer	78	78
M20, MPa (psi)	3.0(430)	1.8(260)
M100	7.6(1110)	5.2(760)
Tensile	15.1(2200)	13.3(1950)
Elongation, %	310	325
Pendulum Rebound (G-H)	--	51.5%
DeMatia Flex 23°C		
KC to 500% Cut Growth	4.5	---
Monsanto Fatigue, 100%	4KC	---
Goodrich Flexometer: 100°C, 22.5%; 1 MPa		
Static Compression	---	7.0%
Heat Build-Up	---	33°C

DUROMETER 93 COMPOUND FOR EASY PROCESSING
PPG

		Banbury 1
NR		70.0
High Styrene Resin, 50% MB		20.0
SBR 1502		20.0
Hi-Sil 210		80.0
100°C Aromatic Resin		10.0
ZMTI		2.0
Octoate Z (Zinc Octoate)		2.0
PEG 3350		2.0
Stearic Acid		2.0
Zinc Oxide		3.0
		Banbury 2
Insoluble Sulfur, 80%		9.0
MBS (MOR)		2.0
DTDM		1.0
TMTM		0.1
Total		**223.1**
Silane Comparison	**As Above**	**+ 2 PHR Silane A189**
Cure Rate 160°C ODR, T90 minutes	12	8.5
Mooney Scorch 130°C, T5 minutes	16	12
Mooney Viscosity, ML100	53	71
Garvey Die Extrusion Rating	10A	9A
Cure 160°C: S/S 22 Minutes; Other Tests 32 minutes		
Durometer, Avg.	93	93
M20 psi (MPa)	455(3.1)	610(4.2)
Tensile	1840(12)	2040(14)
Elongation, %	315	175
Pendulum Rebound (Z)		
At 23°C	32%	29%
At 100°C	46%	49%
Goodrich Flexometer: 100°C, 17.5%; 1 MPa		
Static Compression	1.7%	0
Dynamic Drift	34%	12%
Permanent Set	30%	13%
Heat Build-Up	43°C	34°C

II.

Styrene-Butadiene Polybutadiene

SBR SEAL
R.T. Vanderbilt

Plioflex 1502	100.0
Zinc Oxide	5.0
Stearic Acid	1.5
FEF Black (N-550)	55.0
AGERITE RESIN D	1.75
VANOX ZMTI	0.5
Spider Sulfur	0.25
METHYL TUADS	1.25
ETHYL TUADS	1.25
VANAX NS	2.0
Total	168.50
Physical Properties	
Tensile, MPa (psi)	20.5(2980)
100% Modulus, MPa (psi)	5.0(720)
Elongation, %	380
Hardness, Shore A	72

TREAD RECIPE
Goodyear

Solflex 1216	100.00
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay 29	1.00
Wingstay 100	1.20
Sunolite 240 Wax	2.00
N-299 Carbon Black	50.00
Highly Aromatic Oil	10.00
Amax	1.25
Methyl Tuads	0.25
Sulfur	1.60
Total	**172.30**
Rheometer, 302°F, 1° Arc	
Torque, Min., dNm	13.0
Torque, Max., dNm	47.4
TS 1 minutes	7.0
T'C90, minutes	18.9
ML-4 Min. @ 212°F	97
Original Physical Properties	
Tensile, psi	2732
Elongation, %	397
300% Modulus, psi	1929
Hardness, Shore A	67
Goodrich Flexometer	
Delta T (°F)	59
Pico Abrasion Index	
Index	89
Tear, Die B ppi	147
Goodyear-Healy Rebound, %	
Cold Rebound, %	55.3
Hot Rebound, %	78.6

TIRE TREAD RECIPE
Uniroyal

	1	2	3	4
Flexzone® 7P(6PPD)	----	1	2	3
S-SBR	70.0	70.0	70.0	70.0
HVBR	30.0	30.0	30.0	30.0
N-234 Black	55.0	55.0	55.0	55.0
Aromatic Oil	20.0	20.0	20.0	20.0
Zinc Oxide	3.0	3.0	3.0	3.0
Stearic Acid	1.5	1.5	1.5	1.5
Sunproof® Improved Wax	0.5	0.5	0.5	0.5
Delac® NS (TBBS)	1.0	1.0	1.0	1.0
DPG	0.4	0.4	0.4	0.4
Sulfur	1.8	1.8	1.8	1.8
Mooney Viscosity				
ML (1+4) @ 100°C(212°F)	69	68	67	67
Mooney Scorch				
MS @ 132°C(270°F)				
3 Pt. Rise, minutes	22.0	20.5	19.0	19.5
Cure Meter @ 177°C(351°F)				
ML	7.1	6.5	6.8	6.9
MH	37.8	35.9	36.1	35.5
Ts1	1.95	1.90	1.91	1.85
T90	3.95	3.80	3.70	3.80
Physical Properties @ Room Temperature				
Press Cured 10 minutes @ 177°C(351°F)				
Tensile, MPa(psi)	22	23	21	22
	(3260)	(3180)	(3020)	(3190)
Elongation, %	550	570	560	570
300% Modulus, MPa(psi)	9.2	8.8	8.5	8.4
	(1330)	(1280)	(1230)	(1220)
Shore A Hardness	65	64	64	64
Tear, Die C, kN/m(lb-in.)	64	69	65	63
	(370)	(397)	(373)	(360

TREAD RECIPE
Goodyear

Budene 1207	50.00
Plioflex 1712C	68.75
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay 29	1.00
Wingstay 100	1.25
Sunolite 240 Wax	2.00
N-299 Carbon Black	75.00
Highly Aromatic Oil	31.25
Amax	1.25
Methyl Tuads	0.25
Sulfur	1.60
Total	**237.35**
Rheometer, 302°F, 1° Arc	
Torque, Min.	6.8
Torque, Max.	33.5
TS1, minutes	9.5
T'C90, minutes	18.3
Cure-25' @ 302°F	
Tensile, psi	2168
Elongation, %	502
300% Modulus, psi	1131
Hardness, Shore A	62
Goodrich Flexometer	
Delta T(°F)	68
DIN Abrasion	
Avg. Mass Loss Mgm.	100.4
Tear, Die B ppi	330
Goodyear-Healy Rebound, %	
Cold Rebound, %	50.5
Hot Rebound, %	68.4

TREAD STOCK
Goodyear

Plioflex 1712C	68.75
Budene 1255	68.75
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay 29	1.00
Wingstay 100	1.25
Sunolite 240 Wax	2.00
N-299 Carbon Black	75.00
Highly Aromatic Oil	12.50
Amax	1.25
Methyl Tuads	0.25
Sulfur	1.60
Total	**237.35**
Rheometer, 302°F, 1° Arc	
Torque, Min.	7.4
Torque, Max.	32.6
TS 1 minutes	9.7
T'C90, minutes	20.9
Cure-25' @ 302°F	
Tensile, psi	2344
Elongation, %	518
300% Modulus, psi	1197
Hardness, Shore A	63
Goodrich Flexometer	
Delta T(°F)	74
DIN Abrasion	
Avg. Mass Loss Mgm.	122.1
Tear, Die B ppi	259
Goodyear-Healy Rebound, %	
Cold Rebound, %	46.3
Hot Rebound, %	65.1

DUROMETER 62 COMPOUND FOR LT TREAD
PPG

Banbury 1	
SSBR 750	75.0
SMR 5	25.0
N220	48.0
Ciptane I	12.0
Aromatic Oil	7.0
HPPD	1.0
Stearic Acid	1.0
MC Wax	2.0
Banbury 2	
Zinc Oxide	2.5
Sulfur	1.3
TBBS	1.0
DCBS	0.5
Total	**176.3**
Specific Gravity	1.15
Cure Rate 160°C, T90	8.5 minutes
Mooney Scorch 130°C	23 minutes
Viscosity ML 100	67
Cure: 15 minutes @ 160°C	
Durometer	62
M30, MPa (psi)	7.5(1100)
Tensile	20(2900)
Elongation, %	630
MG Trouser Tear, kN/m (PPI)	15.8(90K)
PICO Abrasion Index	111 (25 mg loss)
Dynamic Properties, Cure: 25 minutes @ 160°C	
Pendulum Rebound (Z)	
@ 23°C	38%
@ 100°C	57%
Goodrich Flexometer: 100°C; 17.5%; 1 MPa	
Static Compression	25%
Dynamic Compression	16%
Drift	13%
Set	15%
Heat Build-Up	49°C

DUROMETER 62 COMPOUND FOR LT TREAD
Continued

DeMattia Cut Growth 23°C			
500% Growth			22 kilocycles
DMA: 1 Hz; 15% Strain			
	E'MPa	**E", MPa**	**Tan Delta**
@ 0°C	25	7.3	0.300
@ 30°C	13	----	----
@ 60°C	----	----	0.249

DUROMETER 65 COMPOUND, HIGH PERFORMANCE TREAD
PPG

	Banbury 1	Banbury 2
SBR 1721	41.0	
SBR 1712	41.0	
BR1203	40.0	
Ciptane III	20.0	
HAF N339	65.0	
Aromatic Resin 100°C	13.0	
Aromatic Oil	20.0	
HPPD	2.0	
TMQ	1.0	
Stearic Acid	2.0	
PEG 3350		1.0
Zinc Oxide		3.0
TBBS		1.5
DTDM		0.6
TMTD		0.1
Sulfur		1.3
Total		252.5
Specific Gravity		1.14
Cure Rate 160°C, T90		7.0 minutes
Mooney Scorch 130°C, T5		15 minutes
Viscosity, ML 100		54
Cure: 12 minutes @ 160°C		
Durometer		63
M20, MPa (psi)		0.86(125)
M300		6.8(1000)
Tensile		18(2670)
Elongation, %		670
PICO Abrasion Index		95
DeMattia 23°C, 500% Cut Growth 40 kilocycles		
Dynamic Properties, Cure: 20' @ 160°C		
Pendulum Rebound: @ 23°C		43.9%
@ 100°C		59.0%
DNA: 1 Hz; 20% Strain:		
E' @ 30°C, MPa		23.3
E' @ 90°C		8.0
E" @ 0°C		17.4
Tan Delta @ 80°C		0.290

DUROMETER 65 COMPOUND, HIGH PERFORMANCE TREAD Continued

Goodrich Flexometer: 100°C; 22.5%; 1 MPa	
Static Compression	24%
Dynamic Compression	12%
Permanent Set	15%
Heat Build-Up	48°C
Monsanto Fatigue, 100%	75 kilocycles

DURO 68, LOW ROLLING RESISTANCE PASSENGER TREAD
PPG

	Banbury 1
SBR 1204	50.0
BR 1203	25.0
NR-SMR5	25.0
HAF N-339	37.0
Hi-Sil 210	10.0
Ciptane I	10.3
HA Oil	7.0
Aromatic 100°C Resin	3.0
Zinc Oxide	1.0
Stearic Acid	1.0
HPPD	1.5
	Banbury 2
Sulfur	1.5
TBBS	2.05
Total	**177.35**
Specific Gravity	1.13
Cure Rate 150°C, T90	13.5 minutes
Mooney Scorch 130°C, T5	26 minutes
Viscosity, ML100	75
Cure: 15 minutes @ 150°C	
Durometer	68
M100 MPa (psi)	2.6(380)
Tensile	24.2 (3500)
Elongation, %	520
Trouser Tear, Kn/m (psi)	5.8(33)
PICO Abrasion Index	137
Dynamic Properties, Cure: 25 minutes @ 150°C	
Pendulum Rebound (Z) %	
At 23°C	51.4
At 100°C	63.2
DMA: 1 Hz; 12.5% Strain	
E’ 30°C	12.4 MPa
E” 0°C	3.4 MPA
Tan Delta: 0°C	0.19
60°C	0.156

DUROMETER 70 COMPOUND, HIGH PERFORMANCE TREAD
PPG

SSBR 756		56.0
BR 1220		50.0
SMR CV60		10.0
Filler		75.0
Vestenamer 8012		10.0
MC Wax		1.0
Amide Wax		1.0
Zinc Oxide		1.0
Sulfur		2.0
TBBS		2.0
HMT		2.0
HPPD		2.0
TMQ		1.0
Specific Gravity		1.14
		Black Control
Hi-Sil 190G	25.0	0
SAF N121	50.0	75.0
Naphthenic Oil	10.0	17.0
Cure Rate 160C, T50 minutes	4.8	3.4
Mooney Scorch 121C T5 min.	30+	30+
Mooney Viscosity, ML100	68	51
Cure: 10’/15’ @ 160C		
Durometer at 23C	70	71
at 100C	61	64
Original		
M300, Mpa	9.1	14.5
Tensile	19	18
Elongation, %	540	365
Aged 700 hours at 90C		
Durometer	84	88
Tensile, Mpa	15	14
Elongation, %	130	70
PICO Abrasion Index, 23C/100C	162/103	143/103
MG Trouser Tear, kN/m, 23C/100C	15/7.7	6.9/2.2

DUROMETER 70 COMPOUND, HIGH PERFORMANCE TREAD, Continued

Goodrich Flexometer Heat Build-Up, °C		48		42
Dynamic Modulus, DMA, 1 Hz; 15%	0°C	60°C	0°C	60°C
E’, MPa	26	15	23	15
E”, MPa	7.2	3.8	5.3	3.3
Tangent Delta	0.279	0.254	0.251	0.221

DUROMETER 74, WET TRACTION, TEAR STRENGTH
PPG

	Banbury 1
SBR 1721	60.0
BR 1203	40.0
Ciptane I	40.0
SAF N110	36.0
Aromatic Oil	6.0
Aromatic 100°C Resin	20.0
HPPD	2.0
TMQ	1.0
Stearic Acid	2.0
PEG 3350	1.2
	Banbury 2
Zinc Oxide	3.0
Sulfur	1.3
TBBS	1.5
DTDM	1.2
TMTD	0.1
Total	**215.3**
Specific Gravity	1.15
Cure Rate 160°C, T90	7.5 minutes
Mooney Scorch 130°C, T5	16 minutes
Viscosity, ML100	60
Cure: 12 minutes @ 160°C	
Durometer	74
M20, MPa (psi)	1.2 (175)
M300	9.4(1370)
Tensile	22.5(3270)
Elongation, %	650
MG Trouser Tear Kn/m (PPI)	21 (119)
PICO Abrasion Index	95
Dynamic Properties: Cure: 22 minutes @ 160°C	
Pendulum Rebound: @ 23°C	29.6%
@ 100°C	59.4%

DUROMETER 74, WET TRACTION, TEAR STRENGTH Continued

DMA: 1 Hz: 15% Strain	
E' 30°C MPa	39.2
E'90°C MPa	9.8
E" 0°C MPa	28.0
Tan Delta	0.254
Goodrich Flexometer: 100°C; 22.5%; 1 MPa	
Permanent Set	5.8
Heat Build-Up	41°C
DeMattia Cut Growth, 500%	18 kilocycles

TIRE TOE STRIP COMPOUND

Uniroyal

	1	2
Flexzone® 7P	----	3.0
Sunproof® Improved Wax	----	1.0
Natural Rubber	25.0	25.0
Cis BR	75.0	75.0
N-330 Black	75.0	75.0
Aromatic Oil	15.0	15.0
Homogenizing Agent	8.0	8.0
Tackifying Resin	4.0	4.0
Zinc Oxide	5.0	5.0
Stearic Acid	1.5	1.5
Delac® NS	1.5	1.5
CTP	0.2	0.2
Insoluble Sulfur, 80% Oiled	3.75	3.75
Mooney Viscosity		
ML (1+4) @ 100°C	70	71
Physical Properties at Room Temperature		
Press Cured 10 minutes @ 176°C		
Tensile, MPa	17.9	18.8
Elongation, %	310	320
300% Modulus, MPa	15.0	15.3
Hardness, Shore A	74	76
Tear, Die C, kN/m	42	45
Bent Loop, 50 pphm Ozone, 40°C (Condition)		
OK		72
VVS		
VS		
S		
C	8	
Dynamic Ozone Belt, 50 pphm Ozone		
Hours to Crack	8	72
Pico Abrasion Index	193	191

DUROMETER 90 COMPOUND FOR ROLLS
PPG

BANBURY	
SMR-CV	10.0
SBR 1900	20.0
SBR 1502	80.0
Hi-Sil 233S*	90.0
Mercapto Silane A189	2.4
Aromatic 100°C Resin	10.0
Titanium Dioxide	3.0
ZMTI	1.0
Stearic Acid	4.0
Zinc Octoate	2.0
PEG 3350	2.0
Mill	
Zinc Oxide	3.0
Insoluble Sulfur 80%	9.0
MBS (MOR)	2.0
DTDM	1.0
Total	**239.4**
Specific Gravity	1.26
Cure Rate 150°C, T90	26 minutes
Mooney Scorch, 121°C, T5	19 minutes
T30	30+ minutes
Viscosity, ML 100	66
Garvey Extrusion, 120°C	
Die Swell	2%
Edge-Surface Rating	8A
Cure: 40 minutes @ 150°C	
Durometer @ 23°C	91
Durometer @ 100°C	82
M300, MPa (psi)	11.0(1600)
Tensile	20.8 (3000)
Elongation	230%
Pendulum Rebound (Z): @ 23°C	23
Pendulum Rebound (Z): @ 100°C	60
PICO Abrasion, mg Loss @ 70°C	25
PICO Abrasion, mg Loss @ 100°C	45

*PPG Siam Silica

DUROMETER 93 COMPOUND FOR ROLLS
PPG

	Banbury	Mill
SBR 1502	83.0	
SBR 1904	14.0	
NR	10.0	
Hi-Sil 255GM	80.0	
100°C Resin	15.0	
TMQ	1.0	
Zinc Octoate	2.0	
PEG 3350	2.0	
Zinc Oxide		3.0
Stearic Acid		2.0
Insoluble Sulfur		7.0
MBS (MOR)		2.0
HMT (Hexa)		2.0
TMTM		0.7
Specific Gravity	1.26	
Silane A189	0	2.0
Cure Rate MDR 150°C, T50 min.	5.7	4.6
Cure Rate MDR 150°C, T90 min.	10	9.2
Mooney Scorch 121°C, T5 min.	7	18
Mooney Viscosity, ML 100	66	67
Durometer: 23°C	94	92
100°C	85	83
Abrasion: NBS Index	133	163
Abrasion: PICO @ 100°C, mg loss	80	54
Abrasion: Taber (H22), mg loss	151	218
Goodrich Flexometer: 100°C, 17%, 1 MPa		
Heat Build-up	26°C	17°C
Dynamic Drift, %	10	3.3
Permanent Set, %	12	4.5
Pendulum Rebound (Z)		
23°C	32	27
100°C	45	51
M300, MPa	4.8	10
Tensile	18	22
Elongation, %	385	240

CREPE SOLE FORMULATIONS
R.T. Vanderbilt

	High Quality	Standard Quality	Firm Cellular
Plioflex 1502	100.0	50.0	100.0
SBR 4681	---	50.0	---
Budene 1208	---	16.7	---
Pliolite S-6F	36.0	30.0	72.5
Extending Resin	12.0	12.0	---
Processing Oil	8.0	20.0	12.3
Stearic Acid	1.75	2.5	---
Zinc Oxide	4.0	3.5	3.0
AGERITE STALITE S	2.0	2.0	1.0
DIXIE CLAY	---	75.0	---
McNAMEE CLAY	55.0	70.0	---
Hi-Sil 243-LD	46.0	25.0	60.0
Whiting	20.0	---	---
Titanium Dioxide	5.0	---	---
Yellow Iron Oxide	0.3	---	---
Diethylene Glycol	---	---	2.5
Opex-93	2.5	5.5	---
Celogen AZ	---	---	2.0
Sulfur	3.0	2.4	3.0
BIK	4.0	2.2	---
ALTAX	0.25	---	---
AMAX	---	0.5	1.5
Total	299.8	367.3	257.8
Properties			
Hardness, Shore A	48	42	88
Density, Mg/m^3	0.55	0.50	0.95
Tear, Die A, kN/m(pli)	3.5(20)	2.1(12)	---
Abrasion Resistance, NBS	---	---	30

SOLE FORMULATIONS
R.T. Vanderbilt

	High Quality	Standard Quality	Oil Resistant
Plioflex 1502	94.0	90.0	30.0
SBR 1805	12.0	21.0	15.0
Neoprene W	---	---	50.0
BUDENE 1208	---	---	10.0
Pliolite S-6F	55.0	30.0	20.0
Extending Resin	25.0	30.0	---
Processing Ol	10.0	13.0	15.0
Stearic Acid	3.0	3.0	2.0
Zinc Oxide	4.0	4.0	2.0
Magnesium Oxide	---	---	2.0
AGERITE RESIN D	1.5	1.5	---
AGERITE STALITE S	---	---	2.0
Hi-Sil 143LD	55.0	---	50.0
DIXIE CLAY	---	250.0	---
Diethylene Glycol	3.0	1.0	1.0
VANTARD PVI	0.3	0.3	---
Sulfur	3.0	2.5	2.5
ALTAX	2.5	2.4	1.5
METHYL TUADS	0.5	0.6	---
VANAX DOTG	---	---	1.0
Total	268.8	449.3	204.0
Properties			
Hardness, Shore A	90	92	70
Tensile, MPa (psi)	14(2030)	7(1020)	10(1450)
Elongation, %	600	550	350
Density, Mg/m^3	1.15	1.55	1.25
Abrasion Resistance, NBS	50	20	50

CELLULAR SHOE SOLING
Uniroyal

	A	B		
SBR 8107	100.00	100.00		
SBR-Styrene Resin MB	30.00	30.00		
HiSil 233	30.00	30.00		
Suprex Clay	100.00	100.00		
Picco 100	10.00	10.00		
Octamine®	2.00	2.00		
Stearic Acid	1.00	1.00		
Zinc Oxide	5.00	5.00		
Circosol 4240	10.00	10.00		
Celogen 754A	6.00	----		
DNPT	----	4.00		
Naugex® MBTS	0.80	0.80		
DOTG	0.20	0.20		
BIK®-OT	----	2.00		
Carbowax 3350	0.50	1.50		
Spider Sulfur	2.50	1.70		
Total	**298.00**	**298.20**		
Rheometer, 163°C(325°F)				
Time, ts2 min.	5:40	5:09		
Time, tc'50 min.	7:45	6:10		
Time, tc'90 min.	10:35	9:05		
90% Torque, lbf-in	46.0	32.6		
N.m.	5.3	3.8		
Precure	**A1**	**A2**	**B1**	**B2**
Time @ 157°C(315°F), min.	13	--	13	--
Time @ 163°C(325°F), min.	--	14	--	14
Shrinkage, L&W, %	0.2-0.8	0.8-0.4	1.5-2.1 blisters	Very bad
Specific Gravity	0.36	0.39	0.36	
Compression Set, %	12.1	12.8	11.9	
Shore A Hardness	46	55	52	

Samples normalized 2.5 hours at 121°C(250°F). Shrinkage after 6 hours at 100°C(212°F).

CELLULAR SHOE SOLING

Uniroyal

	1	2
SBR 8107	100.00	----
Neoprene W	----	100.00
SBR-Styrene MB	30.00	25.00
Picco 100	10.00	----
Stearic Acid	3.00	2.00
Octamine®	1.00	2.00
Magox-OP	----	4.00
Suprex Clay	55.00	50.00
Hi-Sil 233	35.00	40.00
Whiting	15.00	30.00
Zinc Oxide	5.00	5.00
Circosol 4240	10.00	18.00
Carbowax 3350	0.50	----
BIK®-OT	2.00	2.00
Retarder ESEN®	0.75	----
Diethylene GLycol	1.25	----
Naugex® MBTS	1.00	----
DPG	0.25	----
Elasto-O-Sperse PB (DETU)-75	1.25	----
Sulfur	3.00	----
OPEX 80	3.50	3.50
Total	**275.75**	**282.75**
Precure		
Time, min.	12.5	9
Temp., °C	153	168
Expansion Oven		
Time, min.	15	15
Temp., °C	153	153
Test Data		
Shrinkage 12 hours, 100°C, %	1.8	1.2
Specific Gravity	0.52	0.55
Shore A Hardness Skin	60	54
Shore A Hardness Skived	48	41

CELLULAR SHOE SOLING
Uniroyal

	1	2	3
SBR 8107	70.00	70.00	70.00
SBR-S Resin MB	60.00	60.00	60.00
Silica	30.00	30.00	30.00
Hard Clay	100.00	100.00	100.00
Aromatic Resin	10.00	10.00	10.00
Octamine®	2.00	2.00	2.00
Naphthenic Oil Type 103	10.00	10.00	10.00
Stearic Acid	1.00	1.00	1.00
Zinc Oxide	5.00	5.00	5.00
Polyethylene Glycol	1.50	1.50	1.50
BIK®-OT MB (75% Active)	1.30	1.30	2.40
Delac® S	0.80	0.80	0.80
DPG MB (65% Active)	0.45	0.45	0.45
Sulfur	2.50	2.50	2.50
Celogen 765A	4.50	----	----
Celogen 754A	----	4.50	----
DNPT (80%)	----	----	5.00
Total	**299.05**	**299.05**	**300.75**
Press Cure			
Time, min.	13	13	13
Temp., °C	157	157	157
Temp., °F	315	315	315
Specific Gravity	0.41	0.42	0.39
Compression Set, %	13.4	11.4	15.5
Shrinkage, L-W, %	1.1-1.1	1.4-1.5	0.6-0.6
Shore A Hardness	60	60	55

Samples normalized 2.5 hours at 121°C(250°F).
Shrinkage after 6 hours at 100°C(212°F).

TEAR AND ABRASION RESISTANT SOLING

PPG

	Banbury 1
NR	27.0
High Styrene Resin	27.0
BR 1220	40.0
SBR 1502	33.0
Hi-Sil 233	50.0
Aromatic Resin 100°C	10.0
Antioxidant	1.0
Stearic Acid	1.0
Zinc Oxide	5.0
	Banbury 2
PEG	1.0
Sulfur	2.0
MBTS	1.8
MDB	1.0
DPG	0.5
Total	200.3
Specific Gravity	1.10
Cure Rate 160°C, T90	16 minutes
Mooney Scorch 135°C, T5	25 minutes
Viscosity, ML100	71
Durometer	85
M300, PSI (MPa)	900(6.2)
Tensile	2400(16.5)
Elongation	590%
MG Trouser Tear, PPI (bN/m)	120(21)
NBS Abrasion Index	335
Ross Flex Crack Growth	100+ kilocycles (8 mm)

DUROMETER 48 COMPOUND FOR FOOTWEAR
PPG

SBR 1502	80.0
Natural Rubber	20.0
Hi-Sil 190G	50.0
100°C Resin	10.0
Naphthenic Oil	20.0
AO PC	1.0
Stearic Acid	2.0
Zinc Oxide	3.0
PEG 3350	2.0
Sulfur	2.5
TBBS	1.3
MBTS	1.3
ZBDC	0.6
Specific Gravity	1.12
Cure Rate MDR 150°C, T50 minutes	8.8
T90 minutes	13
Mooney Scorch 130°C, T5 minutes	24
Mooney Viscosity, ML 100	41
Cure: 12/22' @ 150°C	
Durometer	48
M300, MPa	2.8
Tensile	17
Elongation, %	700
MG Trouser Tear: kN/m	9.9
Die C Tear: kN/m	26
Lbs/in^2	150
Abrasion Indices: NBS	86
PICO	57
Pendulum Rebound (Z), % 23°C	48
100°C	66

DUROMETER 60 COMPOUND FOR FOOTWEAR
PPG

		Banbury 1
BR 1220		60.0
SMR 5		30.0
SBR 1502		10.0
Ciptane 255LD		44.0
TiO2		14.0
Antioxidant 2246		1.0
Paraffinic Oil		5.0
PEG 3350		1.5
Stearic Acid		1.0
		Banbury 2
Zinc Oxide		5.0
Sulfur		1.0
TBBS		2.0
TMTD		0.3
Total		174.8
Specific Gravity		1.14
Cure Rate 150°C, T90		4.6 minutes
Mooney Scorch 121°C, T5		16 minutes
Viscosity, ML100		66
Cure: 10’/150°C	Original	Shelf Aging 7 Days 50°C
Durometer	61	64
M20, MPa	0.74	0.85
M300	6.3	---
Tensile	14.6	---
Elongation	525%	---
PICO Abrasion Index		89(20 mg loss)
Pendulum Rebound (Z) at 23°C		60.8%
at 100°C		68.4%
Compression Set, 3 Days 100°C		53.0%

DUROMETER 62 COMPOUND FOR FOOTWEAR
PPG

BR 1220		60.0
SSBR 715		25.0
IR 2200		15.0
Hi-Sil 255M		50.0
Vestenamer 8012		10.0
Naphthenic Oil		17.0
ODPA		1.0
Zinc Oxide		1.0
Sulfur		2.0
TBBS		2.0
HMT		2.0
Specific Gravity		1.09
ODR Cure Rate 150C, T50		9.2
Mooney Scorch 121C, T5		17
Viscosity, ML100		68
Cure: 25’/150C		
Durometer	62(23C)	57(100C)
S/S Properties	Original	Aged 700 hrs @ 90C
Durometer	62	81
M300, Mpa	4.2	
Tensile	13	6.8
Elongation, %	695	135
MG Trouser Tear, kN/m		14
Abrasion Indices: PICO		140
NBS		11000
DMA Dynamic Modulus; 1Hz; 15%:	0°C	60°C
E’, MPa	4.3	3.0
E”	0.52	0.31
Tangent Delta	0.122	0.105
Pendulum Rebound (Z): at 23C		53%
at 100C		52%
Kinetic Coefficient of Friction, Wet		1.07

DUROMETER 64, ABRASION RESISTANCE, FOOTWEAR
PPG

		Banbury 1
SBR 1502		100.0
Ciptane I		52.0
Naphthenic Oil		20.0
		Banbury 2
Sulfur		2.3
TBBS		2.0
HMT (Hexa)		1.0
Total		**177.3**
Specific Gravity		1.12
Cure Rate 150°C, MDR		
T50		14 minutes
T90		38 minutes
Mooney Scorch 121°C, T5		30+ minutes
Viscosity, ML 100		68
Garvey Die Extrusion Rating		7A
Cure Rate: 30' @ 150°C	**Original**	**Aged 28 Days @ 70°C**
Durometer: 23°C	64	74
100°C	62	----
M20, MPa (psi)	1.0(145)	----
M300	7.7(1130)	----
Tensile	18(2600)	6.1(900)
Elongation, %	520	145
Abrasion Indices		
PICO	100	
NBS	270	

DUROMETER 65 COMPOUND FOR FOOTWEAR, ZINC-FREE

PPG

		Banbury 1
BR 1220		60.0
SSBR 1205		30.0
SMR 5		10.0
Hi-Sil 255S		42.0
Silane SI 69		3.0
TiO2		15.0
Antioxidant 2246		1.0
Paraffinic Oil		5.0
		Banbury 2
Sulfur		2.0
MBS (MOR)		2.0
Total		170.0
Specific Gravity		1.14
Cure Rate 150°C, T90		17 minutes
Mooney Scorch 121°C, T5		18 minutes
Viscosity, ML100		67
Cure: 20’/150°C	Original	Aged 7 Days 70°C
Durometer	66	72
M20, MPa	0.9	1.1
M300	6.9	---
Tensile	15	13
Elongation	535	385
PICO Abrasion Index		98(29 mg loss)
DeMattia Cut Growth, 500%		40 kilocycles

DUROMETER 68 COMPOUND FOR TRANSLUCENT SOLING
PPG

		Banbury 1
SBR 1502		65.0
SBR 1205		35.0
Hi-Sil 532EP		30.0
Hi-Sil 233		40.0
Naphthenic Oil		30.0
ODPA		1.0
Stearic Acid		2.0
		Banbury 2
PEG 3350		3.0
Zinc Oxide		3.0
Sulfur		2.0
MBS (MOR)		0.8
ZBDC		0.6
Total		**212.4**
ODR Cure Rate, T90 minutes:		
@ 150°C		17
@ 165°C		8
Mooney Scorch, 121°C, T5		30+ minutes
Mooney Viscosity, ML 100		70
Cure:	**25’/150°C**	**15’/165°C**
Durometer	67	69
M300, MPa	2.1	1.8
Tensile	8.9	8.2
Elongation, %	740	810
NBS Abrasion Index	102	

DUROMETER 70 COMPOUND FOR SHOE SOLES
PPG

BR 1220		60.0
NBR 685B		30.0
NR		10.0
Hi-Sil 210		45.0
DOP		5.0
MC Wax		1.0
HPPD		2.0
Zinc Oxide		1.0
Sulfur		2.0
MBTS		2.0
HMT		2.0
Specific Gravity		1.14
Cure Rate MDR 150C, T50 minutes		3.8
T90 minutes		14
Mooney Scorch 121C, T5 minutes		12
Mooney Viscosity, ML100		109
Cure 150C: 13’/23’	Original	Aged 700 hrs 90C
Durometer:	72	86
M300, Mpa	7.0	
Tensile	14	11
Elongation, %	545	160
MG Trouser Tear, kN/m		11.8
Abrasion Indices: NBS		590
PICO		90
Fuel B Immersion 48 hours 23C, % swell		107
Ross Flex, Aged 24 hours 100C, Cut Growth at 100 KC 4.2 mm		
Pendulum Rebound (Z):		
23C		42%
100C		55%

DUROMETER 70 COMPOUND FOR SOLING
PPG

	Banbury 1
SBR 1502	100.0
Hi-Sil 243LD	50.0
Naphthenic Oil	20.0
ODPA	1.0
	Banbury 2
Sulfur	2.3
TBBS	2.0
Hexa (HMT)	1.0
Total	**176.3**
Specific Gravity	1.10
Cure Rate 150°C: T50	14 minutes
T90	38 minutes
Mooney Scorch 121°C: T5	30+ minutes
Viscosity, ML100	94
Garvey Extrusion, 120°C	
Swell	15%
Edge – Surface	6A

Cure: 30’ @ 150°C	**Original**	**Aged 28 Days @ 70°C**
Durometer: @ 23°C	69	76
@ 100°C	67	----
M300, MPa (psi)	5 (730)	
Tensile	18(2600)	6.7(1000)
Elongation, %	645	205
Pendulum Rebound (Z): @ 23°C	53.4%	
@ 100°C	57.6%	
Abrasion Indices: PICO	75	
NBS	202	

DUROMETER 80 COMPOUND FOR FOOTWEAR
PPG

SSBR 715		50.0
BR 1220		40.0
NR		10.0
Hi-Sil 243LD		60.0
100C Resin		10.0
ODPA		1.0
Silane S169		2.0
Zinc Oxide		1.0
Sulfur		2.0
TBBS		1.5
MBTS		1.0
HMT		2.0
Specific Gravity		1.16
Cure Rate 150°C, T50 minutes		7
Mooney Scorch 121°C, T5 minutes		22
Mooney Viscosity, ML 100		126
Garvey Extrusion Rating		5A
Durometer (20 minutes @ 150°C) @ 23°C/@ 100°C		80/74
Stress/Strain (13' @ 150°C)	**Original**	**AGED 700 HRS @ 90°C**
Durometer	76	86
M300, MPa	10	
Tensile	19	12
Elongation, %	475	150
Abrasion Indices: PICO @ 23°C		155
PICO @ 100°C		102
NBS		201
DIN (ml)		0.12
MG Trouser Tear, kN/m		13
Ross Flex, KC to 500%		50
Dynamic Coefficient of Friction,Wet		0.77
DMA Dynamic Modulus: 1 Hz; 15%		
E" at 0°C, MPa		3.1
Tangent delta at 0°C		0.160
E' at 30°C		13
Pendulum Rebound (Z), % @ 23°C		48
@ 100°C		59

DUROMETER 85 COMPOUND FOR SOLING

PPG

BR 1220		40.0
SSBR 303		40.0
SMR CV60		20.0
Hi-Sil 255TLD		60.0
Silane 1289		1.0
100C Resin		10.0
ODPA		1.0
Sulfur		2.0
TBBS		1.5
MBTS		1.0
HMT		2.0
Zinc Oxide		1.0
Specific Gravity		1.15
Cure Rate 160C, MDR, T50		3.8
T90		6.0
Mooney Scorch, 121C T5		30+
Mooney Viscosity, ML100		80
Cured 12/20' @ 160C		
Durometer (button) at 23C		84
at 100C		75
Stress/Strain	Original	Aged 700 hrs @ 70C
Durometer	85	88
M300, MPa	8.9	
Tensile	24	20
Elongation, %	675	430
MG Trouser Tear, kN/m		26
Abrasion Indices: PICO		128
NBS		164
DIN (cc)		0.085
Optical Properties:		
Transmittance, %		9
Haze		74
Dynamic Coefficient of Friction, Wet Aluminum		0.79
Pendulum Rebound (Z) at 23C		32
at 100C		45
Ross Flex Cut Growth, KC to 500%		100+ (6 mm)

CONVEYOR BELT COVER

R.T. Vanderbilt

Natural Rubber, Grade 5	10.0
Plioflex 1500C SBR	70.0
Budene 1207 Polybutadiene	20.0
VANPLAST R	2.0
Sundex 790	7.0
Stearic Acid	1.5
Zinc Oxide	3.0
VANOX 6H	1.1
VANWAX H	2.5
HAF Black (N-339)	50.0
Sulfur	2.5
METHYL TUADS	0.2
Total	181.3
Density, Mg/m^3	1.11
Properties, Cured 20 minutes at 157°C(315°F)	
300% Modulus, MPa (psi)	10.4(1500)
Tensile Strength, MPa (psi)	19.3(2800)
Elongation, %	550
Hardness, Shore A	60
Mooney at 121°C(250°F)	
Scorch, t5, minutes	17
Plasticity, ML	60

FRICTION AND SKIM COAT FORMULATIONS
R.T. Vanderbilt

	First Grade	Heat Resistant
Plioflex 1500C SBR	80.0	90.0
Natural Rubber, Grade	20.0	10.0
VANPLAST R	2.0	2.0
Sundex 790	8.0	5.0
Stearic Acid	1.0	1.5
Zinc Oxide	5.0	3.0
AGERITE RESIN D	1.5	1.1
VANFRE M	7.0	2.5
SRF Black (N-770)	30.0	30.0
FEF Black (N-550)	20.0	20.0
Sulfur	2.3	---
VANAX A	---	1.4
METHYL TUADS	0.2	0.5
AMAX	1.2	---
VANAX NS	---	1.4
Total	178.25	168.4
Density, Mg/m^3	1.12	1.12
Properties, Cured 20 Minutes at 157°C(315°F)		
300% Modulus, MPa (psi)	6.2(900)	3.8(550)
Tensile Strength, MPa (psi)	14.5(2100)	12.4(1800)
Elongation, %	600	850
Hardness, Shore A	55	50
Mooney at 121°C(250°F)		
Scorch, t5, Minutes	40	28
Plasticity, ML	35	35

GOLF BALL CORES

Goodyear

Budene 1207G	100.00
Zinc Oxide	6.00
Zinc Diacrylate	30.00
Wingstay L	0.50
Di-Cup 40C	4.00
Total	**140.50**
Rheometer, 350°F, 0.2° Arc, 100 CPM, 10 min. Motor	
Torque, Min.	0.5
Torque, Max.	39.0
TS 2, minutes	0.3
T'C90, minutes	0.5
ML & MH IN DN-M Units	
Goodyear-Healy Rebound	
Cold Rebound, %	56.3
Original ZWICK	
Cold Rebound, %	80.2
Bashore Rebound, Cold	
% Rebound	66.0
Compression Deflection	
psi @ 10%	841
psi @ 20%	1721
psi @ 30%	2718
psi @ 40%	3950
psi @ 50%	5544
Start Failure	7359
% @ Failure	59

DAMPENING COMPOUND

Goodyear

Budene 1207	50.00
Natsyn 2200	50.00
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay 29	0.75
Wingstay 100	1.00
Sunolite 240 Wax	1.50
GPF, N-650 Carbon Black	40.00
Naphthenic Oil	10.00
Amax	1.25
Unads	0.15
Sulfur	2.50
Total	**162.15**
Rheometer, 300°F, 1° Arc, 100 CPM, 60 In. Motor	
Torque, Min.	6.9
Torque, Max.	38.5
TS 1, minutes	8.0
T'C 90, minutes	14.0
Scorch, MS/270°F	
Minimum	26.0
T5, minutes	20.0
Cure-20' @ 300°F	
Tensile, psi	1700
Elongation, %	380
Hardness, Shore A	62
Goodrich Flexometer	
Delta T (°F)	21
Compression Set, %	
22 Hrs @ 158°F	13.5
Tear, Die C ppi	242
Goodyear-Healy Rebound, %	
212°F	92.1
70°F	87.7
-20°F	52.4

SBR EXTRUSION COMPOUNDS
R.T. Vanderbilt

ASTM D2000	**AA 515**	**AA 720**
Plioflex 1500C	100.0	100.0
Stearic Acid	2.0	2.0
Zinc Oxide	5.0	5.0
AGERITE STALITE S	2.0	2.0
VANFRE AP-2	2.0	2.0
VANPLAST PL	5.0	5.0
Circo Light Oil	15.0	---
NEOPHAX A	25.0	15.0
THERMAX (N-990)	40.0	50.0
FEF Black (N-550)	35.0	60.0
Sulfur	2.0	2.0
MORFAX	1.4	1.4
CUMATE	0.2	---
Total	234.6	244.4
Cured 10 Minutes at 153°C(307°F)		
300% Modulus, MPa (psi)	7.4	---
Tensile Strength, MPa (psi)	11.3(1640)	17.1(2480)
Elongation, %	500	200
Hardness, Shore A	52	71
Tear Die A, kN/m (pli)	15.8(90)	18.5(105)
Cured 5 Minutes at 160°C(320°F)		
300% Modulus, MPa (psi)	6.4(930)	---
Tensile Strength, MPa (psi)	10.5(1530)	220
Elongation, %	510	220
Hardness, Shore A	50	70
Tear Die A, kN/m (pli)	13.2(75)	17.6(100)
Mooney at 121°C(250°F)		
Scorch, t5 minutes	9	13
Plasticity, ML	37	80
Compression Set after 22 Hrs. at 70°C(158°F)		
% Set	31	16

HARD RUBBER FORMULATIONS
R.T. Vanderbilt

	Ordance Battery Case	Caster Wheel	Bowling Ball Cover
SBR, 40% Bound Styrene	100.0	---	---
Plioflex 1502	---	100.0	---
SBR 8107	---	---	100.0
Hard Rubber Dust	125.0	40.0	100.0
HAF (N-339) Carbon Black	---	10.0	10.0
Anthracite Coal Dust	---	---	20.0
Ground Limestone	---	150.0	---
Sunthene 250 Plasticizer	10.0	15.0	20.0
Magnesium Oxide	---	5.0	---
Zinc Oxide	---	---	5.0
Stearic Acid	---	---	2.0
VANFRE M	3.0	---	---
VANAX 808	3.0	0.8	1.5
Armeen HT	---	4.0	---
Sulfur	26.0	30.0	38.0
Total	267.0	354.8	296.5
Properties, Cured Min/°C	20/171	20/171	120/160
Hardness, Shore D	82	75	82
Tensile, MPa (psi)	44(6400)	20(2900)	28(4000)
Elongation, %	3	6	5
Density, Mg/m^3	1.10	1.50	1.14

DUROMETER 64 COMPOUND FOR ABRASION RESISTANCE
PPG

BR 1220		70.0
SMR 60CV		30.0
Hi-Sil 190G		45.0
Silane S169		3.5
CI 100°C Resin		10.0
CI 25°C Resin		10.0
ODPA		1.0
Zinc Oxide		1.0
Sulfur		2.0
TBBS		2.0
HMT		2.0
Specific Gravity		1.11
Cure Rate 150C, T90 minutes		8.2
Mooney Scorch 130C, T5 minutes		15
Mooney Viscosity, ML100		67
Stress/Strain (10’/150)	Original	Aged 700 hrs 90C
Durometer	64	
M300, MPa	5.5	
Tensile	23	11
Elongation, %	780	180
MG Trouser Tear, kN/m		11
PICO Abrasion Index		166
Compression Set, 70 hrs. 100C		78
Pendulum Rebound Z, % at 23C		54
at 100C		64
DeMattia Cut Growth, 500%		9 kc
Goodrich Flexometer, 100C; 22.5%; 1 MPa		
Permanent Set		15%
Heat Build-Up		29°C

DMA Dynamic Modulus; 1 Hz; 15% Deflection	0C	30C	60C
E’, MPa	14	12	10
E”	1.6	1.4	1.2
Tangent Delta	.120	.115	.117

DUROMETER 70 COMPOUND FOR ABRASION RESISTANCE
PPG

BR 1220		70.0
SMR CV60		30.0
Hi-Sil 210		50.0
CI 100°C Resin		5.0
Vestenamer 8012		10.0
ODPA		1.0
Zinc Oxide		1.0
Sulfur		2.7
TBBS		2.0
HMT		2.0
Specific Gravity		1.12
Banbury 1 mixed 6' to 165C		
Cure Rate 150C, T50 minutes		8.0
Cure Rate 150C, T90 minutes		22
Mooney Scorch 121C, T5 minutes		30+
Mooney Viscosity, ML100		88
Stress/Strain (16'/150C)	Original	Aged 170 hrs 110C
Durometer	69	
M20, Mpa	1.3	2.1
M300	7.1	
Tensile	20	7.6
Elongation, %	640	110
PICO Abrasion Index		141
MG Trouser Tear, kN/m		11.3
Compression Set, 70 hrs 100C		85%
Pendulum Rebound Z at 23C		56
at 100C		59
Goodrich Flexometer: 100C; 22.5%; 1 MPa		
Pernament Set		26%
Heat Build-Up		38°C
DMA Dynamic Modulus: 1 Hz; 15%; 60C		
E', Mpa		11.9
E"		1.19
Tandent Delta		0.101

DUROMETER 73 COMPOUND FOR ABRASION RESISTANCE, HIGH VISCOSITY AND TEAR STRENGTH
PPG

BR 1220			65.0
SBR 1215			25.0
SMR CV60			10.0
Hi-Sil 190G			50.0
100°C Resin			10.0
Octenamer 8012			5.0
ODPA			1.0
HMT			2.0
Zinc Oxide			1.0
Sulfur			2.7
TBBS			2.0
Specific Gravity			1.13
Cure Rate 150C: MDR T50 minutes			6.1
Mooney Scorch 121C: T5 minutes			16
Viscosity, ML100			126
Cure: 20’/150C	Original	Oven Aged	
		170 hrs. @ 110C	700 hrs. @ 90C
Durometer	73	84	85
M300, MPa	6.0	--	--
Tensile	20	11	10
Elongation, %	700	150	150
PICO Abrasion Index			136
MG Trouser Tear, kN/m			19
Compression Set, 70 hrs. @ 100C			91%
Goodrich Flexometer: 100C; 22.5%; 1 MPa			
Permanent Set, %			23
Heat Build-Up			31°C
Dynamic Modulus, DMA: 1 Hz; 20% Flex			
E” @ 0C, MPa			3.5
E”@ 60C			1.9
E’@ 60C			20
Tangent Delta @ 60C			0.097

DUROMETER 75 COMPOUND FOR ABRASION RESISTANCE
PPG

			Banbury 1
BR 1220			60.0
Natural Rubber			10.0
SSBR 1205			30.0
Hi-Sil 255S			50.0
Aromatic Resin 100°C			10.0
ODPA			1.0
			Banbury 2
Sulfur			2.0
TBBS			2.0
Total			165.0
Specific Gravity			1.12
Cure Rate: 160°C, T50			2.2 minutes (T90 - 11’)
Mooney Scorch 130°C, T5			8.3 minutes
Mooney Viscosity, ML 100			130
Cure: 15’/160°C	Original	Aged 7D 90°C	Aged 28D 70°C
Durometer: 23°C	76	79	77
100°C	74		
M20 Mpa (PSI)	1.2(175)		
M300	4.0(590)		
Tensile	21(3100)	4.3(630)	13(1900)
Elongation, %	900	105	340
Pendulum Rebound (Z), %			
At 23°C			53.0
At 100°C			51.4
PICO Abrasion			
Weight Loss			16 mg
Index			142
Goodrich Flexometer: 100°C, 22.5%, 1 MPa			
Heat Build-Up			50°C
Permanent Set			32.8%
DMA: 1 Hz; 30°C			
E’, MPa			31
E”			3.7
Tan Delta			0.120

DUROMETER 80 COMPOUND FOR ABRASION RESISTANCE
PPG

		Banbury 1
BR 1220		60.0
Natural Rubber		10.0
SSBR 1205		30.0
Hi-Sil 255S		50.0
Aromatic 100°C Resin		10.0
Antioxidant PC		1.0
		Banbury 2
Zinc Oxide		1.5
HMT		2.0
Sulfur		2.0
TBBS		2.0
Total		168.5
Specific Gravity		1.12
Cure Rate 150°C: T50		7.8 minutes
T90		15 minutes
Mooney Scorch 121°C, T5		30+ minutes
Viscosity, ML100		118
MOR Minimum		7.5
Garvey Extrusion (B)		
% Swell		4
Edge - Surface		7A
Cure: 20'/150°C	Original	Aged 28 Days 90°C
Durometer: 23°C	79	84
100°C	73	--
M300, MPa (PSI)	4.4(640)	--
Tensile	22(3200)	11(1600)
Elongation	955%	150%
Compression Set, 3D 100°C		92.7%
PICO Abrasion		
Weight Loss		21.6 mg
Index		102

DUROMETER 80 COMPOUND FOR ABRASION RESISTANCE Continued

Dynamic Properties, Cure: 30’/150°C	
Pendulum Rebound (Z)	
at 23°C	53
at 100°C	54
Goodrich Flexometer: 100°C; 22.5%; 1 MPa	
Permanent Set	32%
Heat Build-Up	46°C
DMA: 1 Hz; 30°C; 20% Strain	
E’ Mpa	34
E”	3.6
Tangent Delta	0.107

COMPOUND FOR TEAR STRENGTH, ABRASION RESISTANCE
PPG

BR 1220		70.0
SMR CV60		30.0
Hi-Sil 210		50.0
100C Aromatic Resin		13.0
ODPA		1.0
Zinc Oxide		1.0
Sulfur		2.0
TBBS		2.0
HMT		1.0
Specific Gravity		1.13
	Non-Coupled	Coupled 1.5 phr A189
Cure Rate 150C, MDR T50, minutes	6.0	3.9
T90, min.	10	5.0
Mooney Scorch 121C, T5 minutes	30+	10
Viscosity, ML100	100	62
Garvey Die Rating	5A	
Cure at 150C, Minutes	15/25	8/15
Durometer: at 23C	71	71
at 100C	69	69
M300, MPa	5.0	11
Tensile	20	23
Elongation, %	780	585
Aged 700 hours at 90C		
Durometer	85	79
Tensile, MPa	12	10
Elongation, %	210	185
MG Trouser Tear, kN/m	26	5.4
Abrasion Indices: PICO	96	178
NBS	--	650
Compression Set, 70 hrs. 100C, %	90	76
Goodrich Flexometer: 100C, 22.5%; 1 MPa		
Permanent Set, %	--	11
Heat Build-Up, °C	--	28
DeMattia Cut Growth, 500%, kc	8	5
Pendulum Rebound (Z), % at 23C	56	59
at 100C	60	65

DUROMETER 60, RAPID CURE, LOW HEAT BUILD-UP
PPG

		Banbury 1
BR 1220		65.0
SBR 1215		25.0
NR (Milled)		10.0
Hi-Sil 532 EP		60.0
Aromatic 100°C Resin		10.0
ODPA		1.0
		Banbury 2
Sulfur		2.0
TBBS		2.0
Total		175.0
Specific Gravity		1.15
Cure Rate 160°C, minutes		
T50		3.3
T90		5.5
Mooney Scorch 130°C, T5 minutes		13
Viscosity ML100		82
Cure: 13’/160°C		
Durometer		60
M20, MPa (PSI)		0.7(105)
M300		6.9(1000)
Tensile		14.8(2200)
Elongation		570%
PICO Abrasion	At 23°C	At 70°C
MG Loss	31	34
Index	76	88
Compression Set, 3 Days 100°C		67.1%
Dynamic Properties Cure: 23’/160°C		
Pendulum Rebound (Z)		
At 23°C		59.2%
At 100°C		63.8%
Goodrich Flexometer: 100°C; 22.5%; 1 MPa		
Permanent Set		6.4%
Heat Build-Up		18°C

DUROMETER 65, LOW SET & LOW HEAT BUILD-UP
PPG

	Banbury 1
SBR 1502	100.0
Hi-Sil 210	50.0
100°C Aromatic Resin	10.0
ZMTI	2.0
Stearic Acid	2.0
	Banbury 2
Zinc Oxide	3.0
PEG 350	2.0
Sulfur	0.8
TCS (Curite 18)	2.8
	172.6
Specific Gravity	1.13
Cure Rate 150°C, ODR T90	13 minutes
Mooney Scorch 130°C, T5	13 minutes
Mooney Viscosity, ML 4100	70

Cure: 20'/150°C

	Original	**Aluminum Block Aging 3D 121°C**	**Aluminum Block Aging 28D 90°C**
Durometer	64	72	75
M300, psi (MPa)	500(3.4)	----	
Tensile	2900(20)	1400(9.6)	2000(14)
Elongation, %	705	500	600
MG Trouser Tear, PI(KN/M)	80(14)		
Compression Set, 3D 100°C	23%		
Dynamic Properties			
Pendulum Rebound (Z)	@ 23°C	@ 100°C	
	44%	60%	
Goodrich Flexometer (100°C; 22.5%; 1 MPa)			
Heat Build-Up	29°C		
DMA: 1 Hz; 30°C			
Storage Modulus, E'	16 MPa		
Tan Delta	0.140		
Fatigue Properties			
Monsanto (116%), Avg.	120 kilocycles		
DeMattia, 500% Cut Growth	32 kilocycles		

DUROMETER 65 COMPOUND FOR TRANSLUCENCE

PPG

SBR 1502	100.0
Silica	50.0
Nevtac 100	10.0
Naphthenic Oil	5.0
Stearic Acid	2.0
ODPA	1.0
Zinc Oxide	3.0
PEG 3350	1.5
Sulfur	2.0
MOR	1.5
TMTM	0.6
Specific Gravity	1.14

Silica	**Hi-Sil 243LD**	**Ciptane 255LD**
Cure Rate MDR 150°C T50	9.4	7.3
T90	20	20
Mooney Scorch 121°C, T5	30+	30+
Mooney Viscosity, ML 100	71	63
Cured: 20/30’ @ 150°C		
Durometer @ 23°C	63	64
@ 100°C	54	58

Stress/Strain	**Original**	**Aged***	**Original**	**Aged**
Durometer	66	76	67	76
M300, MPa	3.0		5.9	
Tensile	20	9.3	26	13
Elongation, %	750	380	680	310

*Aged 700 hours @ 90°C

MG Trouser Tear, kN/m	17	12
PICO Abrasion Index	55	78
DIN Abrasion, cc	0.18	0.14
Transparency, %	37	20
Haze	87	88
Compression Set, 70 hrs. @ 100°C, %	55	53

DUROMETER 65 COMPOUND FOR TRANSLUCENCE CONTINUED

Pendulum Rebound (Z), %		
@ 23°C	38	41
@100°C	55	60
DeMattia Cut Growth, kc to 500%	2	3
Goodrich Flexometer: 100°C, 22.5%, 1 MPa		
Set, %	Blow-out	4.4
Heat Build-Up, °C		22

DUROMETER 65 COMPOUND FOR TRANSLUCENCE

PPG

SSBR 715	40.0
BR 1220	40.0
IR 2210	20.0
Silica	40.0
Naphthenic Oil	5.0
Zinc Oxide	2.5/1
Sulfur	2.0
ODPA	1.0
MBTS	2.0
Specific Gravity	1.11

Acceleration	Normal	Zinc-Free
Silica	Hi-Sil 233	Hi-Sil 255G
Stearic Acid	2	0
PEG 350	1	0
TMTM	0.5	0
HMT	1	2
Cure Rate 150°C, MDR T50 min.	3.2	6.7
T90 min.	5.8	10
Mooney Scorch 121°C, T5 min.	17	9
Viscosity, ML 100	68	80

Cure @ 150°C	Original	Aged*	Original	Aged*
Durometer	66	75	65	75
M300, MPa	4.5	----	4.5	----
Tensile	7.6	7.2	11	10
Elongation, %	450	210	625	235

*350 Hours @ 90°C

Abrasion Indices: PICO	55	68
NBS	85	5000+
Optical Properties: Hunter Lab Color Quest II		
Transparency, %	36	25
Haze, %	87	88
Yellowness Index	99	128
Pendulum Rebound (Z) @ 23°C	63	58
@ 100°C	70	60
Compression Set: 70 hrs @ 100°C, %	61	79

DUROMETER 70 COMPOUND, NON-DISCOLORING
PPG

			Banbury 1
SBR 1502			100.0
Hi-Sil 210			50.0
Aromatic 100°C Resin			10.0
Aromatic Oil			3.0
Stearic Acid			2.0
Stearic Acid			2.0
Zinc Oxide			3.0
ZMTI			2.0
			Banbury 2
Sulfur			2.0
MBS			1.5
TMTM			0.6
PEG 3350			1.5
Total			175.6
Specific Gravity			1.14
Cure Rate 150°C, T90			14 minutes
Mooney Scorch 130°C, T5			22 minutes
Viscosity, ML100			66
Cure: 20'/150°C	**Original**	**Aged 3 days @ 125°C**	**Aged 21 Days @ 100°C**
Durometer	68	75	79
M300, MPa(psi)	3.6(520)	----	----
Tensile	24(3500)	14.4(2100)	13(1900)
Elongation, %	705	435	350
MG Trouser Tear kN/m (PPI)		17.5(100)	
PICO Abrasion Index		55	
Compression Set 3 Days 100°C		46.3%	
Dynamic Properties: Cure: 30'/150°C			
Pendulum Rebound (G-H)			
@ 23°C		47.8%	
@100°C		66.8%	
Goodrich Flexometer: 100°C, 22.5%, 1 MPa:			
Permanent Set		14%	
Heat Build-Up		45°C	
DeMattia Cut Growth 23°C			
500% Growth		18 kilocycles	
Monsanto Fatigue (100%)		17 kilocycles	

DUROMETER 70 COMPOUND FOR SEMI-OIL RESISTANCE

PPG

SBR 1713		Variable
NBR HR 662		Variable
BR 1220		5
Hi-Sil 243LD		40
Hard Clay		110
100C Resin		10
NBR 1312 DLC		10
Stearic Acid		2
ODPA		1
PEG 3350		2
Zinc Oxide		3
Sulfur		3
MBTS		2
DOTG		1
Specific Gravity		1.40
SBR 1713	100	68
NBR HR662	30	50
Cure Rate 150°C, T50 minutes	7.0	5.5
T90 minutes	12	10
Mooney Scorch 121°C, T5 min.	29	22
Viscosity, ML100	57	60
Durometer	68	73
M300, MPa	6.1	7.8
Tensile	13	14
Elongation, %	605	555
Oven Aged 170 Hrs. 110°C		
Tensile, MPa	12	12
Elongation, %	245	215
Pendulum Rebound (Z), %		
At 23°C	27	22
At 100°C	50	49
MG Trouser Tear, kN/m	21.6	18.4
PICO Abrasion Index	41	41

DUROMETER 80, LOW SET, NON-TRANSLUCENT
PPG

SSBR 715			70
BR 1220			30
Hi-Sil 210			40
Ciptane I			11
100°C Resin			5
Naphthenic Oil			5
Hindered Phenol			1
Sulfur			2
TBBS			2
HMT			2
Zinc Oxide			1
Specific Gravity			1.15
Cure Rate 150°C: T50 minutes			4.0
T90 minutes			28
Mooney Scorch 130°C: T5 minutes			7.0
Viscosity, ML 100			118
Cure:20’/150°C	Original	Aged 170 Hrs/110°C	Aged 700 Hrs./90°C
Durometer: 23°C	82	88	89
100°C	77		
M300, MPa	7.9		
Tensile	14	11	12
Elongation, %	525	130	115
MG Trouser Tear, kN/m		12(66 lbs./in)	
PICO Abrasion Index		101	
Compression Set, 70 hrs./100°C		42%	
Dynamic Properties			
Pendulum Rebound (Z):	@ 23°C	51%	
	@ 100°C	60%	
Goodrich Flexometer: 100°C, 22.5%; 1 MPa			
Dynamic Drift, %		9.7	
Permanent Set, %		13	
Heat Build-Up		29°C	

DUROMETER 80, LOW SET, NON-TRANSLUCENT
Continued

DeMattia Cut Growth, 500% Growth		2 kilocycles	
DMA: 1 Hz;	0°C	30°C	60°C
E’, MPa	35	29	23
E’’	4.4	3.4	2.7
Tangent delta	0.127	0.117	0.118

DUROMETER 90 COMPOUND FOR FLOORING
PPG

Polymers		100
High Styrene Resin		15
Hi-Sil 210		30
Hard Clay		100
25°C CI Resin DLC		12
Sulfur		3
TBBS		2
HMT		2
OTOS*		1
SBR 1502	100	---
SBR 715	---	60
BR 1220	---	30
NR	---	10
*SBR1502 Only		
Cure Rate 150°C, T50 minutes	9.2	6.7
Mooney Scorch, 121°C, T5 min.	21	22
Viscosity, ML100	92	100
Cure at 150°C, minutes	20	20
Durometer: 23°C	88	90
100°C	70	74
M300, MPa	8.9	11.3
Tensile, MPa	18	13
Elongation, %	545	380
Resilience by Pendulum Rebound (Z), %		
23°C	32	38
100°C	40	74
NBS Abrasion Index	40	37
Taber Abrasion, H22; 500 g; 1000 rev; mg. loss	130	105
DeMattia Cut Growth, KC to 500% Growth	4	3

NATURAL RUBBER/BUTADIENE BLEND
Goodyear

SMR-20	50.00
Budene 1207	50.00
Hi-Sil 233	15.00
SI-69	1.50
Zinc Oxide	3.00
Stearic Acid	2.00
Wingstay 29	1.00
Wingstay 100	1.25
Sunolite 240 Wax	2.00
N-299 Carbon Black	45.00
Naphthenic Oil	5.00
Amax	1.50
Methyl Tuads	0.25
Sulfur	1.00
Total	**178.50**
Rheometer, 302°F, 1° Arc	
Torque, Min.	14.5
Torque, Max.	53.6
TS1, minutes	4.5
T'C90, minutes	12.0
Cure-20' @ 302°F	
Tensile, psi	3136
Elongation, %	384
300% Modulus, psi	2362
Hardness, Shore A	70
Goodrich Flexometer	
Delta T(°F)	55
DIN Abrasion	
Avg. Mass Loss Mgm.	79.3
Tear, Die B ppi	458
Goodyear-Healy Rebound, %	
Cold Rebound, %	71.2
Hot Rebound, %	77.5

PRESS MOLDED CLOSED CELL SHEET SPONGE

Uniroyal

	1	2	
Royalene® 525	30.0	30.0	
SBR 8140	75.0	75.0	
Neoprene W	10.0	10.0	
Stearic Acid	4.0	4.0	
Zinc Oxide	7.0	7.0	
Hard Clay	100.0	100.0	
Magnesium Silicate	50.0	50.0	
N550 FEF Black	10.0	10.0	
Petrolatum	10.0	10.0	
Wax	5.0	5.0	
Naphthenic Oil Type 103	45.0	45.0	
Octamine®	1.0	1.0	
Polyethylene Glycol	2.0	2.0	
Sulfur	2.75	2.75	
Naugex® MBTS	0.6	0.7	
DPG MB (65% Active)	0.45	0.45	
BIK®-OT MB (75% Active)	1.33	2.0	
Celogen® 765A	13.0	----	
Celogen® AZ-130	----	12.0	
Total	**367.13**	**366.90**	
Cure Meter, 163°C(325°F)			
ts2, min.	5.9	6.1	
Precure Press			**Expansion Oven**
Time, min.	26	33	90
Temp, °C(°F)	143(289)	138(280)	154(310)
Density, kg/m^3(lb.ft^3)	139(8.7)	133(8.3)	
Shrinkage, L-W, %	1.7-1.9	2.2-2.7	

PRESS MOLDED CLOSED CELL SHEET SPONGE NON-OIL RESISTANT

Uniroyal

	1	2	3
Royalene® 521	80.0	----	----
Royalene® 512	20.0	----	----
Royalene® 525	----	----	35.0
SBR 1506	----	40.0	----
SBR 8140	----	----	81.25
SBR 4906	----	100.0	----
Stearic Acid	1.0	4.0	3.0
Zinc Oxide	4.0	5.0	5.0
Suprex Clay	115.0	100.0	100.0
Mistron Vapor	45.0	45.0	45.0
N550 FEF Black	10.0	10.0	10.0
Petrolatum	8.0	8.0	8.0
Circosol 4240	50.0	45.0	45.0
Sunproof® Improved Wax	----	5.0	5.0
Naugawhite® Powder	----	2.0	----
Sulfur	2.0	2.0	4.0
Naugex® MBTS	1.0	1.0	----
Delac® S	----	----	0.7
ZMBT	----	----	0.7
Celogen® AZ-130	12.0	12.0	12.0
BIK®-OT	2.0	2.0	----
Total	**350.0**	**381.0**	**354.65**
Press Precure - 28 minutes @ 143°C(290°F)			
Oven Expand and Normalize - 1.5 hours @ 160°C(320°F)			
Density, lb/ft3(kg/m^3)	9(144)	9(144)	9(144)

The above compounds are typical 2A1 (RE-41) types.
Adjust the cure and blow systems for 2A2 (RE-42) and 2A3 (RE-43).

PRESS MOLDED CLOSED CELL SHEET SPONGE
Uniroyal

	1	2	3
Royalene® 505	30.00	30.00	30.00
SBR-8140	75.00	75.00	75.00
Neoprene W	10.00	10.00	10.00
Stearic Acid	4.00	4.00	4.00
Zinc Oxide	7.00	7.00	7.00
Suprex Clay	190.00	190.00	190.00
Mistron Vapor Talc	50.00	50.00	50.00
N762 SRF Black	10.00	10.00	10.00
Petrolatum	10.00	10.00	10.00
Circosol 4240	55.00	55.00	55.00
Sunproof® Improved Wax	5.00	5.00	5.00
Sulfur	2.50	4.00	2.50
Delac® S	0.50	0.70	----
ZMBT	0.50	0.70	----
Naugex® MBTS	----	----	0.70
DOTG	----	----	0.15
Celogen AZ-130	----	----	12.00
Celogen 754A	12.00	12.00	----
BIK®-OT	0.40	----	12.50
Carbowax 3350	0.40	----	0.50
Total	**462.30**	**463.40**	**463.35**
Typical Data			
Rheometer @ 163°C(325°F)			
Time, ts2, min.	5:50	6:10	7:18
Time, tc50, min.	8:30	9:00	12:08
90% Torque: lbf-in	26.0	27.0	17.9
N.m	3.0	3.1	2.1
Precure - Press			
Time, min.	28	29	39
Temp., °C	143	143	138
Temp., °F	290	290	280
Expand - Normalize			
154°C(310°F) Hours	1.5	1.5	1.5
Density, lbs./ft^3	9.0	9.0	9.2
Density, kg/m^3	144	144	147

PRESS MOLDED CLOSED CELL SHEET SPONGE
Uniroyal

	1*	2
Royalene® 525	30.00	30.00
SBR 8140	75.00	75.00
Neoprene W	10.00	10.00
Stearic Acid	4.00	4.00
Zinc Oxide	7.00	7.00
Suprex Clay	100.00	100.00
Mistron Vapor	50.00	50.00
N-550 FEF Black	10.00	10.00
Petrolatum	10.00	10.00
Circosol 4240	45.00	45.00
Sunproof® Improved Wax	5.00	5.00
Octamine®	1.00	1.00
Carbowax 3350	2.00	2.00
Sulfur	2.75	2.75
Naugex® MBT	1.00	0.60
BIK®-OT	1.20	6.00
Celogen 780	13.00	----
DNPT 80%	----	11.60
Total	**365.75**	**368.35**
Precure Press		
Time, min.	20	20
Temp., °C	150	135
Temp., °F	302	275
Expansion Oven 90 min. @ 160°C(320°F)		
Density, lbs./ft^3	8.5	8.2
Density, kg/m^3	136	131
Shrinkage, 6 hours @ 100°C	2.0	2.85
50% Compression Set		
22 hours @ R.T., % Set	26	21

*A viable alternative to activated DNPT in sheet sponge.

III.

Butyl
Halobutyl

BROMOBUTYL HIGH TEMPERATURE HOSE

Exxon

Bromobutyl 2244	100
N-330	45
Sunpar 2280	5
Stearic Acid	1
Zinc Oxide	5
MBTS	2
TMTDS	1
MS @ 132°C, 3 Pt. Rise	6.1
ML (1+8) @ 100°C	79.2
Rheometer, 160°C, 3° Arc	
MH, In-Lb	42.4
ML, In-Lb	18.7
T90, Min.	5.65
Ts2, Min.	2.02
Physical Properties, Cured 20' @ 160°C	
Elongation, %	698
Hardness, Shore A	61
Tensile Strength, MPa	17.27
100% Modulus, MPa	1.26
300% Modulus, MPa	6.29
Aged Physical Properties, 70 Hrs. @ 125°C	
Elongation Retained, %	78.5
Hardness Change, Point	3
Tensile Retained, %	91.4
Aged Physical Properties, 70 Hrs. @ 150°C	
Elongation Retained, %	63.6
Hardness Change, Point	3
Tensile Retained, %	53.5
Tear Strength, Die C @ 125°C	27.82
Tear Strength, Die C @ 25°C	48.5
Compression Set, 72 Hrs. @ 70°C	22.7

CHLOROBUTYL STEAM HOSE COMPOUND – TUBE
Exxon

Chlorobutyl 1066	100
Hi-Sil 233	60
N-550	20
Paraffinic Oil	10
Stearic Acid	1
Paracin 1	4
Phenolic Resin Tackifier	3
Antioxidant 2246	1
Diethylene Glycol	2
Magnesium Oxide	2
Zinc Oxide	3
TMTDS	2
MBTS	1
ML (1+8) @ 100°C	75
MS @ 132°C, Min. to 3 pt. Rise	23
Physical Properties, Cured 60' @ 153°C	
300% Modulus, MPa	8.0
Tensile Strength, MPa	11.2
Elongation, %	430
Aged Physical Properties, 14 Days @ 149°C	
100% Modulus, MPa	--
Tensile Strength, MPa	3.3
Elongation, %	90

STEAM HOSE TUBE

R.T. Vanderbilt

Exxon Chlorobutyl 1066	100.0
Hi-Sil 233	60.0
Flexon 765	10.0
Stearic Acid	1.0
SP-1045	3.0
VANOX MBPC	1.0
Diethylene Glycol	2.0
Magnesium Oxide	0.25
Litharge	10.0
END-75	1.0
Total	188.25
Density, Mg/m^3	1.16
Properties, Cured 60 Minutes at 153°C(307°F)	
100% Modulus, MPa (psi)	3.9(560)
Tensile Strength, MPa (psi)	13.5(1960)
Elongation, %	720
Hardness, Shore A	62
Mooney at 100°C(212°F)	
Plasticity, ML (1+8)	66
Compression Set After 22 Hours at 70°C(158°F)	
Set, %	30

DUROMETER 65 COMPOUND FOR STEAM HOSE
PPG

CIIR 1240		100.0
Hi-Sil 233		60.0
Paraffinic Oil		15.0
Stearic Acid		2.0
DEG		3.0
Zinc Oxide		5.0
Magnesia		2.0
ETU (75%)		2.7
Total		187.7
Cure Rate @ 160°C		60’
Mooney Scorch @ 121°C, T5		9’
T35		>30’
Viscosity, ML100		114
Stress-Strain Properties (Cure: 60’/160°C)		
	Original	Aged 3 d @ 121°C
Hardness	65	75
M300	560(3.9)	
T_B	2140(14.7)	1770(12.2)
E_B	660	240
MG Trouser Tear @ 23°C		95(16.6)
@ 100°C		50(8.7)
Compression Set, 3 days @ 100°C		52
DeMattia Flex @ 23°C, KC to 0.6”		15
Yerzley Resilience		50
Water Immersion @ 100°C	Volume %	Hardness
1 Day	10.3	74
7 Days	9.0	71
14 Days	8.6	73

HEAT-RESISTANT CONVEYOR BELT

R.T. Vanderbilt

Exxon Bromobutyl 2244	100.0
FEF (N-550)	45.0
Maglite D	1.0
Carbowax 3350	1.5
Stearic Acid	1.0
VANOX MTI	1.0
Zinc Oxide	3.0
VAROX DCP-40C	2.0
VANAX MBM	1.0
Cured 35>PR at 160°C	
Original/Aged 7 Days at 150°C	
Hardness, Shore A	59/64
Tensile Strength, MPa	11.2/9.1
Elongation, %	250/200

CHLOROBUTYL COVER COMPOUND FOR CONVEYOR BELT
Exxon

Chlorobutyl 1066	100
N-330	25
N-110	25
Paraffinic Oil	5
Stearic Acid	1
Phenolic Resin Tackifier	3
Antioxidant 2246	1
Magnesium Oxide	1
Zinc Oxide	5
TMTDS	1
MBTS	2
ML (1+8) @ 100°C	75
MS @ 126°C, Min. to 5 pt. Rise	23
Physical Properties, Cured 40’ @ 153°C	
Hardness, Shore A	69
300% Modulus, MPa	8.3
Tensile Strength, MPa	19.1
Elongation, %	580
Aged Physical Properties, 16 Hrs. @ 194°C	
Hardness, Shore A	80
100% Modulus, MPa	3.5
Tensile Strength, MPa	4.5
Elongation, %	175

BROMOBUTYL CONVEYOR BELT COVER

Exxon

Bromobutyl 2222	100
N-550	45
Naphthenic Oil	5
Stearic Acid	1
Carbowax 3350	1.5
Magnesium Oxide	1
MBI	1
DiCup 40C	2
HVA-2	1
Rheometer, 171°C, 3° Arc, 30’	
ML, dN-m	23
MH, dN-m	85
Ts2, minutes	1
Tc90, minutes	8
Physical Properties, Cured 12’ @ 180°C	
Hardness, Shore A	56
100% Modulus, MPa	2.7
Tensile Strength, MPa	9.2
Elongation, %	900
Aged Physical Properties, 14 Days @ 150°C	
Hardness, Shore A	51
100% Modulus, MPa	2.4
Tensile Strength, MPa	6.7
Elongation, %	270
Compression Set, 72 Hrs. @ 125°C, %	35

TIRE WHITE SIDEWALL COMPOUND
Uniroyal

	1	2
Naugawhite® Antioxidant	----	1.5
Natural Rubber	35.0	35.0
Chlorobutyl Rubber	50.0	50.0
Royalene® 505	15.0	15.0
Titanium Dioxide	40.0	40.0
Hydrated Aluminum Silicate	20.0	10.0
Zinc Oxide	15.0	15.0
Stearic Acid	1.0	1.0
Sunproof® Improved Wax	3.0	3.0
Tackifying Resins	3.0	3.0
Ultramarine Blue	0.2	0.2
Vultac® 5	1.0	1.0
Delac® NS	1.5	1.5
Insoluble Sulfur, 80% Oiled	1.5	1.5
Mooney Viscosity		
ML (1+4) @ 100°C	32	31
Mooney Scorch, MS @ 132°C		
3 pt. Rise, minutes	12.6	13.1
Physical Properties at Room Temperature		
Press Cured 30 minutes @ 160°C		
Tensile Strength, MPa	17.4	16.8
Elongation, %	630	610
300% Modulus, MPa	5.8	6.1
Hardness, Shore A	51	52
Oven Aging, 1 Month @ 70°C, % Retention		
Tensile Strength, MPa	12.1	14.7
Tensile Strength, % Retained	70	88
Elongation, %	570	580
Elongation, % Retained	90	95
300% Modulus, MPa	8.1	7.4
300% Modulus, % Retained	140	121
Hardness, Shore A	57	55
DeMattia Flexing		
KC to failure	4524	4994
Outdoor Dynamic Flexing		
KC to failure	7155	33030

TIRE INNERLINER COMPOUND

Uniroyal

	1	2
Naugard® Q	----	1.5
Zinc Oxide	1.5	1.0
Sulfur	1.0	1.5
Chlorobutyl 1066	60.0	60.0
Natural Rubber	20.0	20.0
SBR 8401	27.5	27.5
N-660 Black	60.0	60.0
Paraffinic Oil	10.0	10.0
Stearic Acid	1.0	1.0
Hydrocarbon Resin	2.0	2.0
Naugex® MBTS	1.0	1.0
Mooney Viscosity ML (1+4) @ 100°C	49	51
Mooney Scorch, MS @ 132°C		
3 pt. Rise, minutes	16.3	15.9
Physical Properties at Room Temperature		
Press Cured 15 minutes @ 165°C		
Tensile, MPa	14.0	13.8
Elongation, %	650	670
300% Modulus, MPa	5.4	4.9
Hardness, Shore A	55	53
Tear, Die C, kN/m	28.0	29.5
Oven Aging, 2 Weeks @ 70°C		
Tensile Strength	10.1	12.2
Tensile Strength, % Retention	72	88
Elongation, %	410	500
Elongation, % Retention	63	74
300% Modulus, MPa	7.9	7.1
300% Modulus, % Retention	146	144
Hardness, Shore A	62	59
Hardness, points change	+7	+6
Tear, Die C, kN/m	20	22
Tear, Die C, % Retention	71	74
Flex Fatigue to Failure		
Kilocycles	1408	2107
DeMattia Flex, Kilocycles	6800	7100

CHLOROBUTYL INNERLINER COMPOUND
Exxon

Chlorobutyl 1065	100
N-660	60
Naphthenic Oil	8
Stearic Acid	2
Phenolic Resin Tackifier	4
Struktol 40 MS	7
Magnesium Oxide	0.15
Zinc Oxide	3
Sulfur	0.5
MBTS	1.5
ML (1+4) @ 100°C	43
MS @ 135°C, Min. to 3 pt. Rise	12
Physical Properties, Cured 25’ @ 160°C	
Hardness, Shore A	55
300% Modulus, MPa	3.2
Tensile Strength, MPa	8.1
Elongation, %	860
Tear Strength, kN/m @ 100°C	27
Aged Physical Properties, 3 Days @ 125°C	
Hardness, Shore A	74
100% Modulus, MPa	8.3
Tensile Strength, MPa	8.3
Elongation, %	330

BROMOBUTYL INNERLINER COMPOUND

Exxon

Bromobutyl 2222	100
N-660	60
Naphthenic Oil	8
Stearic Acid	1
Phenolic Resin Tackifier	4
Struktol 40 MS	7
Magnesium Oxide	0.15
Zinc Oxide	3
Sulfur	0.5
MBTS	1.5
ML (1+4) @ 100°C	70
MS @ 135°C, Min. to 3 pt. Rise	14
Rheometer, 160°C, 3° Arc	
MH-ML, lb-in	21
Ts2, minutes	4
Tc90, minutes	18
Physical Properties, Cured 25’ @ 160°C	
Hardness, Shore A	56
300% Modulus, MPa	2.7
Tensile Strength, MPa	9.2
Elongation, %	900
Tear Strength, kN/m @ 100°C	27

INNERLINERS
R.T. Vanderbilt

	1	2	3
Chlorobutyl 1065	100.0	80.0	---
Chlorobutyl 1066	---	---	60.0
Natural Rubber	---	20.0	25.0
Plioflex 1778	---	---	20.6
N-660 GPF Black	60.0	55.0	---
N-330 HAF Black	---	---	40.0
Whiting (OMYA)	---	---	40.0
Phenol-Formaldehyde Resin	4.0	8.0	4.0
Struktol 40 MS	7.0	10.0	---
Naphthenic Oil	8.0	---	10.0
Stearic Acid	2.0	2.0	1.0
Magnesium Oxide	0.15	---	0.5
Zinc Oxide	3.0	3.0	3.0
Sulfur	0.5	0.5	---
ALTAX	1.5	1.5	1.0
Vultac 5	---	---	1.3
METHYL TUADS	---	---	0.25
Mooney Viscosity at 100°C, ML			
1+4 Minute Reading	43	52	54
Mooney Scorch, MS			
Minutes to 3 Pt. Rise, 135°C	12	12	---
Minutes to 5 Pt. Rise, 121°C	---	---	15
Original/After Aging 3 Days at 125°C in Air			
Cure Time, Minutes at 160°C	25	25	20
Shore A Hardness	55/74	63/76	55
300% Modulus, MPa	3.2/8.3	3.6/6.8	5.2
Tensile Strength, MPa	8.1/8.6	10.8/8.7	11.1
Elongation, %	860/330	850/510	520
Tear Strength, kN/m at 100°C	27	25	28
Air Permeability, 66°C			
Q x 10^3	3.0	6.0	8.2
General Purpose Rubber Carcass Adhesion, 100°C			
kN/m	4.4 1*	15.0 S/1*	---
*S denotes stock tearing; 1 denotes interfacial separation			
Monsanto Fatigue-to-Failure			
Extension, %	140	140	100
Kilocycle to Failure	415	434	236

INNERLINER
R.T. Vanderbilt

Exxon Bromobutyl 2255	100.0
Carbon Black GPF (N-660)	50.0
Flexon 876	8.0
Stearic Acid	2.0
Maglite D	0.5
Mineral Rubber	7.0
Sulfur	0.5
ALTAX	1.5
Mooney Viscosity at 100°C	
1+8 Min. Reading	65
Mooney Scorch at 135°C	
Min. to 5 Pt. Rise	22
Rheometer at 150°C	
ML/MH, lb/in	18/44
tc90, Min.	37
Monsanto Tel-Tak, kPa (30 s, 16 oz.)	
• To Self	240
• To 100% NR Carcass	125
• To 50/50 NR/SBR Carcass	80
• To 25/75 NR/BR Chafer	85
Green Strength, MPa x 10^{-2}	27
Decay Time to 50% of Initial Stress, s	32
Press Cured Tc90 Minute at 150°C	
Initial/After Aging 3 Days at 125°C in Air	
Hardness, Shore A	44/48
100% Modulus, MPa	1.1/1.5
300% Modulus, MPa	3.7/4.8
Tensile Strength, MPa	11.8/10.4
Elongation at Break, %	756/687
Tear Strength, kN/m	40/36
Monsanto Fatigue-to-Failure	
K cycles, 140% Extension	
Mean	40
Range	25-55

INNERLINER
Continued

Static Peel Adhesion to 100% NR Carcass, kN/m * = Separation with stock tearing	35*
Permeability to Air at 65°C $cm^3.cm.cm^{-2}.s^{-1}.atm^{-1}.10^{-8}$	3.0
Water Vapor Permeability at 65°C $g.cm.cm^{-2}.h^{-1}.atm^{-1}.10^{-6}$	2.5

CHLOROBUTYL EXHAUST HANGER COMPOUND

Exxon

Chlorobutyl 1068	100
N-330	40
Paraffinic Oil	15
Stearic Acid	1
Zinc Oxide	5
TMTDS	1
MBTS	2
ML (1+8) @ 100°C	53
MS @ 127°C, Min. to 3 pt. Rise	10
Rheometer, 171°C, 3° Arc, 30’	
ML, lb-in	11.2
MH, lb-in	34.0
Ts2 minutes	1.6
Tc90, minutes	4.3
Physical Properties, Cured 60’ @ 153°C	
Hardness, Shore A	51
100% Modulus, MPa	1.0
300% Modulus, MPa	4.7
Tensile Strength, MPa	13.1
Elongation, %	620
Tear Strength, Die C, kN/m	40
Aged Physical Properties, 70 Hours @ 125°C	
Hardness Change, Points	9
Tensile Change, %	-13
Elongation Change, %	-34

DUROMETER 45 COMPOUND FOR SQUASH BALLS
PPG

Bromobutyl X2		75.0
SMR		25.0
Hi-Sil 233		20.0
Hi-Sil EP		20.0
Barytes		40.0
Naphthenic Oil		10.0
ODPA		1.0
Stearic Acid		2.0
Diethylene Glycol		2.0
Zinc Oxide		10.0
Sulfur		0.6
CBS		1.5
TMTD		1.0
Total		208.1
Cure Rate, 90% ODR		
At 150°C		17
At 166°C		9
Mooney Scorch at 121°C, T5		11
Viscosity, ML100		54
Stress-Strain Properties (Cure: 10’/166°C)		
	Original	Aged 3 d @ 150°C
Hardness	45	70
M300	130(0.9)	
T_B	1460(10)	430(2.9)
E_B	840	350
Trouser Tear, Grooved; lbs./in.		95(17)
Goodyear Rebound, %		38.4
PICO Abrasion Index		32 (Chunking)
Compression Set, 70 hr. @ 100°C		39

CHLORINATED BUTYL PHARMACEUTICAL CLOSURE

Engelhard

Chlorobutyl HT 10-66	100.00
Maglite D	2.00
Satintone W	120.00
Paraffin Wax	2.00
Paricin 1	2.50
Zinc Oxide	5.00
NA-22	1.50

Specific Gravity	1.42
Processibility Properites	
Mooney Scorch @ 270°C(MS), t_3, mins.	26
Mooney Viscosity, ML (1+8), 212°F, units	69
Physical Properties, Press Cure: 60 secs @ 420°F	
Hardness	61
300% Modulus, psi	325
Tensile Strength, psi	900
Ultimate Elongation, %	640

BROMOBUTYL PHARMACEUTICAL CLOSURE
Exxon

Bromobutyl 2244	100
Whitex	60
Stearic Acid	1
AC-617A	3
Wax	2
White Oil	5
Diak No. 1	1
ML (1+8) @ 100°C	53
MS @ 132°C, Min. to 3 pt. Rise	4.6
Physical Properties, Cured 10' @ 171°C	
Hardness, Shore A	45
100% Modulus, MPa	0.7
300% Modulus, MPa	1.2
Tensile Strength, MPa	6.0
Elongation, %	640
Tear, Die C @ 25°C	15
@ 160°C	5.5
Compression Set, 22 Hrs. @ 70°C, %	16

DUROMETER 55 COMPOUND FOR GENERAL MRG
PPG

Butyl 365		100.0
Hi-Sil 233		40.0
Naphthenic Oil		5.0
KP 140		3.0
Stearic Acid		1.0
Zinc Oxide		5.0
PEG 4000		3.0
Sulfur		As noted
TMETD		2.0
DPTH		1.0
Sulfur	1.7	0.5
Cure Rate @ 160°C, 90% ODR	20	13
Mooney Scorch @ 121°C, T5`	19	19
Viscosity, ML 100	77	80
Garvey Extrusion @ 121°C		
Rate, Ft./Min.	5	5
Swell, %	35	35
Edge & Surface	10A	10A
Stress-Strain Properties		
Cure @ 160°C	30’	20’
Hardness	57	56
M300	190(1.3)	130(0.9)
Tensile	2020(14)	1950(13)
Elongation	750	850
Aged 3 Days @ 121°C		
Hardness	60	62
M300	370(2.5)	240(1.6)
Tensile	1600(11)	1300(9.0)
Elongation	750	860
Trouser Tear, Grooved, lbs./in.		
At 20°C	60(11)	80(14)
At 100°C	22(3.8)	40(7.0)
PICO Abrasdion	39	44
Compression Set, 70 h @ 100°C	65	53

DUROMETER 55 COMPOUND FOR GENERAL MRG
Continued

DeMattia Flex @ 20°C KC to 0.6” cut growth	9	60
Water Immersion @ 100°C		
1 Day	5.8	6.2
3 Days	8.2	8.7
7 Days	7.9	10.9

LOW RESILIENCE COMPOUND
R.T. Vanderbilt

Exxon Butyl 268	100.0
THERMAX N-990 Carbon Black	15.0
HAF (N-330) Carbon Black	30.0
Flexon 845 Naphthenic Oil	10.0
Zinc Oxide	5.0
Sulfur	1.0
ETHYL CADMATE	2.0
ALTAX	0.5
Total	183.5
Properties, Cured 30 minutes at 160°C	
Hardness, Shore A	48
Tensile, MPa (psi)	15(2200)
Elongation, %	640
Density, Mg/m^3	1.11
Resilience at 20°C, %	11
Resilience at 100°C	~55

HIGH HARDNESS COMPOUND
R.T. Vanderbilt

Exxon Chlorobutyl 1066	100.0
Magnesium Oxide	1.0
Stearic Acid	1.0
VANOX MBPC	1.0
VANWAX H	2.0
FEF (N-550) Carbon Black	15.0
HAF (N-350) Carbon Black	35.0
CRF (N-326) Carbon Black	40.0
VANWAX H Special	10.0
Zinc Oxide	5.0
ALTAX	2.0
SP-1055 Resin	4.0
Total	216.0
Properties, Cured 30 minutes at 160°C	
Hardness, Shore A	82
Tensile, MPa (psi)	12(1700)
Elongation, %	240
Density, Mg/m^3	1.17

Notes:

IV.

Neoprene

AIR CONDITIONER HOSE

DuPont Dow

Neoprene WRT	100
SBR 1502	5
Maglite D	9
Octamine	1
PE 617A	3
HiSil 233	20
N762	50
Atomite Whiting	20
EPON 828	8
Zinc Oxide	2
Calcium Oxide	4
END-75	1
Total	**223**
Physical Properties – Original	
Press Cured: 45 minutes @ 160°C	
T-B, psi	982
E-B, %	495
Shore A, points	76
Compression Set, Method B	
22 Hours @ 100°C	88

DUROMETER 65 COMPOUND FOR HOSE
PPG

		Banbury 1
Neoprene WRT		100.0
BR 1203		3.0
Magnesia		3.0
Hi-Sil 210		30.0
FEF N550		30.0
ODPA		2.0
LP Oil		10.0
Stearic Acid		2.0
		Banbury 2
Zinc Oxide		5.0
ETU 75%		0.75
Total		185.75
Cure Rate 154°C, T90		20 minutes
Mooney Scorch 121°C, Minutes:		
T5		14
T35		26
Viscosity, ML 100		60
Cure: 40'/154°C		
Durometer		66
M20, MPa (PSI)		1.0(144)
M300		9.1(1330)
Tensile		14.4(2100)
Elongation		415%
Aging at 100°C	3 Days	14 Days
Durometer	73	78
Tensile, MPa (PSI)	14.3(2100)	14.0(2050)
Elongation %	375	335
Percent E_B Retained	90	81
Cure: 50'/154°C		
Pendulum Rebound (Z)		
At 23°C		38
At 100°C		61
Compression Set: 3 Days 100°C		48%
DeMattia Cut Growth 23°C		
500% Growth		30 kilocycles

DUROMETER 63 COMPOUND FOR HOSE
PPG

	Banbury 1
Neoprene	100.0
BR 1220	5.0
Hi-Sil 532EP	50.0
Hi-Sil 243LD	20.0
Naphthenic Oil	15.0
ODPA	2.0
	Banbury 2
Zinc Oxide	5.0
Magnesium Oxide	2.0
Stearic Acid	2.0
Armoslip CP	1.0
Specific Gravity	1.44

Neoprene Type	GRT	WRT
PEG 3350	--	3
TMETD	--	1
HMT	--	2
Cure Rate MDR 154C, T50	8.2	8.1
T90	23	21
Mooney Scorch 121C, T5	30+	12
Mooney Viscosity, ML100	32	47
Cured 20'/30' @ 154C		
Durometer: at 23C	63	62
at 100C	56	55

Stress/Strain	Original	Aged*	Original	Aged
Durometer	63	80	62	74
M300, MPa	2.7	--	2.4	--
Tensile	13	11	10	9
Elongation, %	920	585	810	555

*Aged 72 hours @ 100C

Immersions, 72 hrs.	ASTM #1 Oil 100C	Water 60C	ASTM #1 Oil 100C	Water 60C
% Volume Increase	-0.8	7.3	1.0	11.1
Durometer	58	58	55	55
Tensile	12	12	10	11
Elongation, %	730	815	755	780

DUROMETER 63 COMPOUND FOR HOSE
Continued

MG Trouser Tear, kN/m	29	29
Die C Tear, kN/m	42(240)	29(165)
Compression Set, 70 hrs. @ 100C, %	96	82
Pendulum Rebound (Z), %		
At 23C	42	42
At 100C	51	51
DeMattia Cut Growth, KC to 500%	30	13
Kinetic Coefficient of Friction		
Wet Aluminum	1.06	1.23

DUROMETER 80 COMPOUND FOR HOSE, BRASS ADHESION

PPG

Neoprene W	100.0
Magnesium Oxide	4.0
Silene D	50.0
Hard Clay	20.0
GPF N660	40.0
Naphthenic Oil	18.0
Microcrystalline Wax	2.0
Stearic Acid	2.0
Resorcinol Resin	2.0
Wingstay 100	1.5
Zinc Oxide	5.0
DOTG	1.0
TMTM	1.0
Sulfur	1.0
Cyrez 936P	5.0
Total	252.5
Cure Rate @ 154°C, 90% ODR	15’
Mooney Scorch @ 121°C, T5	26’
Viscosity: ML 100	88
ODR Minimum	7.4
Stress-Strain Properties (Cure: 30’/154°C)	
Hardness	79
M100	710(4.9)
Tensile	1640(11.2)
Elongation	290
Compression Set, 70 hr @ 100°C	76%
Brass Strip Adhesion (lbs./in), 25’/154°C	30

DUROMETER 70 COMPOUND FOR HOSE, SURFACE GLOSS
PPG

Neoprene WHV	50.0
Neoprene W	25.0
Neoprene WB	25.0
Magnesium Oxide	3.0
Silene D	75.0
Hard Clay	90.0
Aromatic Oil	30.0
TCP	20.0
Red Oxide	3.0
Stearic Acid	2.0
Zinc Oxide	2.0
Trimethyl Thiourea	1.0
Total	329.0
Cure Rate @ 154°C; 90% ODR	23
Mooney Scorch @ 121°C, T5	19
Viscosity: ML 100	82
ODR Minimum	6.7
Stress-Strain Properties (Cure: 40’/154°C)	
Hardness	68
M300	590(4.0)
Tensile	1010(6.9)
Elongation	600

NON-BLACK HOSE COVER
R.T. Vanderbilt

Neoprene W	100.0
Stearic Acid	0.5
VANOX MBPC	2.0
Magnesium Oxide (High Activity)	4.0
DIXIE CLAY	140.0
Light Process Oil	15.0
Picco Resin 6100	5.0
VANWAX H	2.0
Zinc Oxide	5.0
END-75	1.0
ALTAX	0.75
Total	275.25
Properties, Cured 30 Minutes at 152°C(307°F)	
100% Modulus, MPa (psi)	2.9(425)
300% Modulus, MPa (psi)	10.8(1575)
Tensile Strength, MPa (psi)	12.3(1825)
Elongation, %	360
Hardness, Shore A	62
Tear Strength, Die C	
kN/m(pli)	45.4(260)
Mooney at 121°C(250°F)	
Scorch, t5, minutes	22
Plasticity, MS	26

DUROMETER 75 COMPOUND FOR BELTS
PPG

		Banbury 1
Neoprene GN		100.0
Magnesia		1.0
MT N990		100.0
Hi-Sil 233		20.0
LP Oil		10.0
Wingstay 100		2.0
ODPA		1.0
MC Wax		2.0
Stearic Acid		2.0
		Banbury 2
Zinc Oxide		5.0
Total		243.0
Specific Gravity		1.45
Cure Rate 165°C: T75		5 minutes
T90		15 minutes
Mooney Scorch 121°C, T5		29 minutes
Viscosity ML 100		77
Stress-Strain Cure 20/165°C	Original	Aged 72 hr. 100°C
Durometer	75	83
M100, MPa (PSI)	4.6(670)	6.8(1000)
Tensile	12.3(1800)	11.6(1700)
Elongation	320%	250%
Dynamic Properties		
DeMattia Flex 23°C, Not Punched		
100 Kilocycles, No Cracking		
Goodrich Flexometer: 100°C; 20%; 1 MPa		
Static Compression		9.4%
Dynamic Compression		0.2%
Set		4.8%
Heat Build-Up		35°C

V-BELT RECOMMENDATION

DuPont Dow

Neoprene GRT	100
N650 Carbon Black	35
Agerite Stalite	2
Maglite D	4
HiSil 233	15
MBTS	0.5
Stearic Acid	1
SRF 1501	2
Zinc Oxide	5
Cyrex 963	6
Total	**170.5**
Physical Properties	
Tensile, psi	2828
Elongation, %	301
Hardness, Shore A	83
Die C Tear @ RT, ppi	**292**
Block Adhesion	
Polyester	64
Fiberglass	40
Kevlar®	53

NEOPRENE SEAL
R.T. Vanderbilt

Neoprene W	100.0
Stearic Acid	1.0
Magnesium Oxide	4.0
AGERITE STALITE S	2.0
SRF Black (N-774)	40.0
Calcium Carbonate	60.0
Dioctyl Sebacate (DOS)	7.5
VANWAX OZ	1.5
Zinc Oxide	5.0
VANAX DOTG	0.7
UNADS	0.75
Spider Sulfur	0.4
THIATE EF-2	0.75
Total	223.65
Physical Properties	
Tensile, MPa (psi)	14.3(2080)
100% Modulus, MPa (psi)	3.1(440)
Elongation, %	310
Hardness, Shore A	66

DUROMETER 40 COMPOUND FOR ROLLS & GASKETS
PPG

Neoprene W		35.0
Neoprene WHV		65.0
Hi-Sil 233		25.0
Plasticizer SC		25.0
Stearic Acid		1.0
ODPA		2.0
Magnesia		4.0
Zinc Oxide		5.0
Ethylene Thiourea		0.5
Total		162.5
Stress –Strain Properties (Cure: 20'/154°C)	Original	Aged 3 D @ 100°C
Hardness	42	46
M300	360(2.5)	430(2.9)
Tensile	2000(13.7)	2100(14.3)
Elongation	820	760
Compression Set		
1 Day @ 70°C		24%
3 Days @ 100°C		44%
Oil Immersion, 3 Days @ 100°C	ASTM #1	ASTM #3
% Volume Change	-9	74
Hardness	46	27
M300	430(2.9)	330(2.2)
Tensile	2170(14.9)	1500(10.3)
Elongation	740	630

NEOPRENE ROLL COMPOUND

DuPont Dow

Neoprene GRT	70
Neoprene WHV	30
Stearic Acid	1.5
Wingstay AZ	2
Octamine	2
Magnesium Oxide	4
N990 Carbon Black	30
Factice	20
Aromatic Process Oil	40
Zinc Oxide	5
AC Polyethyene 1702	2
Total	**206.5**
Physical Properties – Original	
Tensile, psi	1500
Elongation, %	500
Hardness, Shore A	40

AIR SPRING
DuPont Dow

Neoprene GRT	100
Stearic Acid	0.5
Maglite D	4
Naugard PANA	2
Vanwax H Special	3
N990 Carbon Black	15
N550 Carbon Black	15
Sunthene 4240 Naphthenic Oil	10
Tenex 3901*	5
Zinc Oxide	5
Total PHR's	**159.5**
Original Physical Properties	
Tensile Strength @ Break, psi	2950
Elongation @ Break, %	960
Shore A Hardness, Points	49

* Wood Rosin

STARTING POINT FORMULATION FOR WET SUIT
DuPont Dow

Neoprene GW	100
Maglite D	2
Octamine	2
Stearic Acid	0.5
N772 Carbon Black	15
Circosol 4240	15
Calcium Carbonate	25
Brown Factice	25
CBS	0.5
Zinc Oxide	5
ETU	0.5
Azodicaronamide Blowing Agent	10
Total	**220.5**
Density, g/cc	0.25
Cure (1st Stage)	8 min. @ 160°C
Cure (2nd Stage)	15 min. @ 170°C

EXTRUSION COMPOUND, MICROWAVE CURE
R.T. Vanderbilt

ASTM D2000	BE 620
Neoprene TW 100	100.0
Maglite D	2.0
Stearic Acid	1.0
SRF Black (N-774)	65.0
Sundex 790	20.0
VANOX 2-AZ	2.0
VANWAX H Special	2.0
Zinc Oxide	5.0
END-75	2.0
Desical P	5.0
Total	204.0
Cured 20 minutes at 160°C(320°F)	
Tensile Strength, MPa (psi)	15.2(2200)
Elongation, %	300
Hardness, Shore A	65
Heat Aged 70 Hrs. at 100°C(212°F)	
Tensile Strength, % Change	-2
Elongation, % Change	-9
Hardness, Points Change	+4
Compression Set after 22 Hrs. at 100°C(212°F)	
% Set	12
ASTM #3 Oil Aged 70 Hrs. at 100°C(212°F)	
Tensile Strength, % Change	-35
Elongation, % Change	-40
Hardness, Points Change	-17
Volume Change, %	+40

EXTRUSION COMPOUNDS
R.T. Vanderbilt

ASTM D2000	**BC 515**	**BC 720**
Neoprene TW	100.0	100.0
Stearic Acid	1.0	1.0
Maglite D	4.0	4.0
VANFRE AP-2	2.0	2.0
VANPLAST R	5.0	5.0
AGERITE STALITE S	2.0	2.0
NEOPHAX A	35.0	15.0
Sundex 790	10.0	---
FEF Black (N-550)	20.0	30.0
THERMAX (N-990)	40.0	55.0
Zinc Oxide	5.0	5.0
THIATE U	1.5	1.5
Total	225.5	220.5
Cured 30 Minutes at 153°C(307°F)		
200% Modulus, MPa (psi)	4.3(630)	13.3(1930)
Tensile Strength, MPa (psi)	11.7(1700)	16.5(2390)
Elongation, %	400	250
Hardness, Shore A	51	68
Tear Die A, kN/m(pli)	10.6(60)	13.2(75)
Cured 5 Minutes at 171°C(340°F)		
200% Modulus, MPa (psi)	5.4(780)	13.8(2000)
Tensile Strength, MPa (psi)	13.0(1880)	16.5(2400)
Elongation, %	370	240
Hardness, Shore A	53	69
Tear Die A, kN/m(pli)	6.2(35)	12.3(70)
Mooney at 121°C(250°F)		
Scorch, t5, minutes	9	6
Plasticity, ML	37	61
Compression Set after 22 Hrs. at 70°C(158°F)		
% Set	34	16

FORMULATIONS FOR MILITARY APPLICATION
R.T. Vanderbilt

MIL-R-6855, Class II & IV	Grade 50	Grade 60	Grade 70
Neoprene WHV	100.0	100.0	100.0
Maglite D	4.0	4.0	4.0
AGERITE STALITE S	2.0	2.0	2.0
WINGSTAY 100-AZ	2.0	2.0	2.0
Stearic Acid	0.5	0.5	0.5
VANFRE M	1.0	1.0	1.0
THERMAX N-990 Carbon Black	60.0	85.0	90.0
SRF (N-774) Carbon Black	---	---	20.0
Arizona 208 Plasticizer	15.0	15.0	15.0
Zinc Oxide	5.0	5.0	5.0
Ethylene Thiourea, 75% in binder	0.95	0.95	0.95
Total	190.45	215.45	240.45
Properties, Cured 30 minutes at 153°C(307°F)			
Hardness, Shore A	48	59	68
Tensile, MPa (psi)	12(1750)	12(1750)	10(1450)
Elongation, %	550	450	350
Density, Mg/m^3	1.35	1.39	1.43
Compression Set after 70 hours at 100°C(212°F)			
Method B, % Set	23	22	22
After Oven Aging 70 hours at 100°C(212°F)			
Hardness, Points Change	+8	+8	+6
Tensile Change, %	+5	0	0
Elongation Change, %	-13	-16	-16
Weight Change, %	-3	-1	-2
After ASTM #1 Oil Aging 70 hours at 100°C(212°F)			
Hardness, Points Change	0	+3	+3
Tensile Change, %	+3	+8	+10
Volume Change, %	0	-2	-1
After Water Aging 70 hours at 100°C(212°F)			
Hardness, Points Change	+3	+2	+2
Volume Change, %	+6	+5	+4
Resistance to			
Ozone (1 ppm, 20% strain)	No cracks	No cracks	No cracks
Cold Bend at -55°C(-67°F)	No cracks	No cracks	No cracks
Crazing of acrylics (Class IV)	None	None	None

FLAME RESISTANT BRIDGE BEARING PAD
R.T. Vanderbilt

Neoprene WRT	100.0
Magnesium Oxide	4.0
Zinc Oxide	5.0
Stearic Acid	0.5
WINGSTAY 100AZ	2.0
AGERITE STALITE S	2.0
SAF (N-110) Carbon Black	20.0
Hi-Sil 233	15.0
Dioctyl Sebacate	10.0
Ethylene Thiourea, 75% in binder	1.0
METHYL TUADS	0.4
Total	159.9
Properties, Cured min/°C	20/153
Hardness, Shore A	60
Tensile, MPa (psi)	20(2850)
Elongation, %	500
Density, Mg/m^3	1.37
Tear Strength, Die C, kN/m (pli)	35(200)
Compression Set after 22 Hours	100°C(212°F)
Method B, % Set	28

HIGH HARDNESS COMPOUND

R.T. Vanderbilt

Neoprene WM-1	80.0
Neoprene FB	20.0
Magnesium Oxide	4.0
Stearic Acid	0.5
AGERITE STALITE S	2.0
THERMAX (N-990) Carbon Black	80.0
SRF (N-774) Carbon Black	100.0
Circo RPO Naphthenic Oil	8.0
Zinc Oxide	5.0
VANAX DOTG	1.0
UNADS	1.0
Sulfur	0.5
Total	302.0
Properties, Cured min/°C	30/153
Hardness, Shore A	92
Tensile, MPa (psi)	12(1700)
Elongation, %	120
Density, Mg/m^3	1.55

DUROMETER 67 PLY SKIM FOR RFL FABRIC AND CORD
PPG

	Banbury 1
Neoprene GN	100.0
BR 1203	5.0
Hi-Sil 210	40.0
Hi-Sil 532EP	15.0
N774	10.0
DOS	10.0
Magnesium Oxide	2.0
Stearic Acid	2.0
DPPD 100	2.0
SDPA 29	1.0
	Banbury 2
Zinc Oxide	5.0
Total	192.0
Specific Gravity	1.40
Cure Rate 154°C, T50	6.7 minutes
T90	26 minutes
Mooney Scorch 121°C, t5	30+ minutes
Viscosity, ML 100	71
Cure: 35’/154°C	
Durometer	67
M300, MPa (PSI)	4.4(640)
Tensile	11.6(1700)
Elongation	720%
MG Trouser Tear, kN/m (PPI)	16.2(83)
Compression Set, 3 Days 100°C	69.7%
Glass Transition Tg (E”)	-26°C to -39°C

DUROMETER 60 COMPOUND FOR PLY ADHESION

PPG

		Banbury 1
Neoprene WRT		100.0
BR 1203		5.0
Hi-Sil 210		40.0
FEF N550		25.0
DOS		10.0
Magnesium Oxide		2.0
Stearic Acid		2.0
ODPA		2.0
Amide Wax		0.7
		Banbury 2
Zinc Oxide		3.0
Sulfur		0.5
TMTM		1.0
DOTG		1.0
Total		192.2
Specific Gravity		1.46
Silane A189	0	1
Cure Rate 154°C, T50 minutes	14	15
Mooney Scorch 121°C T5 minutes	30+	30+
Viscosity, ML100	634	100
Mill Tack	Good	Fair
Cure: 35’/154°C		
Durometer	58	60
M300 MPa	5.0	10.8
Tensile	17	21
Elongation	680%	535%
Aging 7 Days 121°C		
Durometer	78	78
Tensile, MPa	17	16
Elongation	200%	165%
MG Trouser Tear: kN/m(Lbs./in)	23.3(135)	12.8(73)
Ply Adhesion: 0.5 mm Skim Between 2 RFL Cord Plies		
Static Strip N/13 mm	96	79
Rubber Cover	100%	30%
Tension Fatigue Life:		
Kilocycles/mm Separation	1.9	0.7
Rubber Cover	100%	80%

DUROMETER 53 COMPOUND FOR PLY ADHESION
PPG

		Banbury 1
Neoprene WRT		100.0
BR 1203		5.0
Hi-Sil 210		50.0
DOS		10.0
Magnesium Oxide		2.0
Stearic Acid		2.0
SDPA29		1.0
DPPD		2.0
DEG		2.0
		Banbury 2
Zinc Oxide		5.0
Sulfur		0.5
TMTM		1.0
DOTG		1.0
Total		181.5
Specific Gravity		1.38
Cure Rate 154°C, T50		14 minutes
Mooney Scorch 121°C, T5		25 minutes
Viscosity, ML100		56
Cure: 25'/154°C	Original	Aged 500 Hrs 90°C
Durometer	53	75
M300, MPa (PSI)	2.8(410)	--
Tensile	15(2200)	16(2300)
Elongation	830%	580%
MG Trouser Tear, kn/m (PPI)		19.2(110)
Glass Transition (DMA) °C		
E' Onset		33
E' Finish		22
E" Peak		27
Tan Delta Peak		22

DUROMETER 70, TEXTILE ADHESION & MILL RELEASE
PPG

		Banbury 1
Neoprene GRT		100.0
BR 1203		3.0
Magnesia		3.0
Hi-Sil 210		15.0
Hi-Sil 532EP		20.0
FEF N550		25.0
LP Oil		10.0
Stearic Acid		2.0
ODPA		2.0
R-F Resin		1.0
		Banbury 2
Zinc Oxide		5.0
HMMM 65%		3.0
Total		189.0
Specific Gravity		1.36
Cure Rate 154°C, T70		16 minutes
Mooney Scorch 121°C, T5		15 minutes
T35		30+ minutes
Viscosity, ML100		54
Mill Sticking: 35°C		Slight-Moderate
60°C		Very Slight
Cure: 20’/154°C	Original	Aged 3 Days 121°C
Durometer	60	83
M300, MPa (PSI)	10.0(1460)	--
Tensile	14.7(2150)	15.2(2300)
Elongation	485%	225%
Adhesion to Untreated Nylon Fabric		
Strip Peel, Minimum	Lbs./in	kN/m
25’/154°C	60	10.5
50’/154°C	60	10.5
Fatigue Properties		
DeMattia Cut Growth		
500% Growth		55 kilocycles
Monsanto Fatigue, 100%		32 kilocycles

DUROMETER 70 COMPOUND FOR LOW SET
PPG

		Banbury 1
Neoprene WRT		95.0
BR 1203		5.0
Magnesia		2.0
Ciptane		25.0
Silene 732D		20.0
Hard Clay		60.0
ODPA		1.0
Stearic Acid		2.0
Naphthenic Oil		8.0
Castor Oil Ester		3.0
Polyethylene LMW		3.0
		Banbury 2
Zinc Oxide		4.0
PEG 3350		4.0
ETU		0.4
Total		232.4
Specific Gravity		1.58
Cure Rate 154°C (Slope Max.)		21 minutes
Mooney Scorch 121°C, T5		22 minutes
Mooney Viscosity ML100		67
Cure: 30’/154°C	Original	Aged 72 Hrs. 121°C
Durometer	70	79
M300, MPa (PSI)	6.6(960)	
Tensile	9.6(1400)	8.6(1250)
Elongation,%	530	260
Compression Set	72 Hrs. 100°C	22 Hrs.70°C
Percent	26	10
DeMattia Cut Growth, KC to 500%, at 23°C		75
At 100°C		35
Water Immersion 100°C, % Volume Increase		
1 Day		11
7 Days		21
14 Days		16
Garvey Extrusion, Edge-Surface		10A

DUROMETER 70, SEMI-CONDUCTIVE/DIRECT BONDING
PPG

Neoprene GRT			80.0
Hydrin T			40.0
BR 1220			5.0
Hi-Sil 243LD			15.0
N351			25.0
ODPA			2.0
Stearic Acid			2.0
Naphthenic Oil			5.0
R-F Resin			1.0
HMMM 65%			3.0
Zinc Oxide			5.0
Magnesia			4.0
MBTS			1.0
Specific Gravity			1.40
Cure Rate, MDR 155C, T50 minutes			5.7
Mooney Scorch, 121C, T5 minutes			15
Mooney Viscosity, ML100			56
Surface Resistivity (D257), ohms/sq.			4×10^6
Static Decay Time (ML-B-81705B)			<0.01 seconds
Strip Adhesion to RFL Nylon, N/25 mm			250
Cure at 155C: 15 & 25 min.	Original	70 hrs. 100C	700 hrs. 90C
Durometer at 23C	69	78	82
at 100C	63		
M300, MPa (psi)	8.1(1200)		
Tensile	16	20	20
Elongation, %	615	460	325
Compression set, %, 70 hrs. 100C			86
Pendulum Rebound, % at 23C			36
at 100C			55
DeMattia Cut Growth, 500%			100+ KC

DUROMETER 70, SEMI-CONDUCTIVE/DIRECT BONDING CONTINUED

Low Temperature Properties, DNA, 1 Hz:	
Dynamic Modulus, E’, MPa	
-30C	2100
-20C	830
-10C	155
0C	65
10C	45
20C	35
Glass Transition (E” max.), T_g	-24°C

DUROMETER 80 COMPOUND FOR ADHESION
PPG

		Banbury 1
Neoprene WRT		94.0
BR 1203		3.0
HSR 60%		16.0
Hi-Sil 532 EP		35.0
Hi-Sil 210		20.0
SRF N762		50.0
Plasticizer SC		5.0
DOS		10.0
Stearic Acid		2.0
DPPD 100		2.0
SDPA 29		1.0
Magnesium Oxide		2.0
		Banbury 2
Zinc Oxide		5.0
Sulfur		0.5
TMTM		1.0
DOTG		2.5
Total		249.0
Specific Gravity		1.41
Cure Rate 154°C, T70		20 minutes
Mooney Scorch 121°C, T5		30+ minutes
Viscosity, ML 100		59
Cure: 30’/154°C	Original	Aged 7 Days 100°C
Durometer	78	88
M300, MPa (PSI)	7.9(1150)	--
Tensile	11.0(1600)	11.4(1670)
Elongation, %	440	200
MG Trouser Tear		11 kNm
Cure: 40’/154°C		
Compression Set 3 Days 100°C		69%
DeMattia Cut Growth, 500%		9 kilocycles

DUROMETER 80 COMPOUND FOR ADHESION
Continued

Pendulum Rebound (Z): at 23°C	24%
at 100°C	39%
TG; Rheometrics (Maximum Tan Delta)	-38°C
Adhesion to RFL Tire Cord:	
Pull-Out	55 lbs./in.
Rubber Cover	100%

DUROMETER 60, TEAR STRENGTH & HEAT RESISTANCE
PPG

Neoprene GN		100.0
BR 1203		5.0
Hi-Sil 210		22.0
HAF N330		23.0
Naphthenic Oil		10.0
ODPA		2.0
Stearic Acid		1.0
Zinc Oxide		5.0
Magnesia		4.0
Total		172.0
Mooney Scorch @ 121°C; T5		30’
Viscosity, ML 100		63
Stress Strain Properties (Cure: 20’/150°C)	Original	Aged 3 D @ 100C
Hardness	62	76
M300	760(5.2)	--
T_B	2600(17.8)	2800(19.2)
E_B	720	480
Die C Tear	285(50)	340(59)
Trouser Tear (Cut Groove)	100(17.5)	55(9.6)
Compression Set 1 Day @ 100°C		73%
Yerzley Resilience		65%
Varsol Immersion 3 Days @ 23°C		
% Volume Change		40
Hardness		43

DUROMETER 70, TEAR STRENGTH & HEAT RESISTANCE
PPG

Neoprene W		100.0
BR 1203		3.0
Hi-Sil 210		26.0
HAF N326		30.0
Magnesia		4.0
ODPA		1.0
Stearic Acid		1.0
Flexricin 9		3.0
Naphthenic Oil		5.0
Zinc Oxide		5.0
Sulfur		1.0
DPG		0.5
TMTM		0.5
Ethylene Thiourea		0.2
Total		180.2
Mooney Scorch, T5		
At 121°C		14’
At 138°C		6’
Viscosity ML100		77
Stress Strain Properties (Cure: 20’/150°C)		
	Original	Aged 3 days @ 135°C
Hardness	70	84
M300	1270(8.6)	
Tensile	2600(17.9)	2400(16.5)
Elongation	500	280
Die C Tear	250(43.5)	260(45.4)
Trouser Tear, Cut Groove		
At 23°C	110(19.2)	40(7)
At 70°C	50(8.8)	25(4.5)
Compression Set 3 Days @ 100°C		80%

DUROMETER 65 COMPOUND FOR ABRASION RESISTANCE

PPG

Neoprene W		100.0
BR 1203		5.0
Hi-Sil 215		40.0
Mercapto Silane A189		1.0
Magnesia		4.0
ODPA		2.0
Stearic Acid		2.0
Ethylene Thiourea		0.2
Sulfur		0.2
DTDM		1.0
TMTM		0.5
DPG		0.5
Zinc Oxide		5.0
Total		161.4
Cure Rate @ 150°C, T90		38’
Mooney Scorch @ 121°C, T5		20’
Viscosity, ML100		110
Stress Strain Properties (Cure: 30’/150°C)		
	Original	Aged 3 days @ 100°C
Hardness	66	72
M300	1620(11.2)	
Tensile	3800(26.2)	3270(22.5)
Elongation	700	470
Abrasion Indices		
PCIO		119
NBS		175
Compression Set 3 Days @ 100°C		40%

PRESS MOLDED CLOSED CELL SHEET SPONGE
OIL RESISTANT MEDIUM SWELL
Uniroyal

Recipe	**1**	**2**
Neoprene W	100.0	60.0
SBR-8107	----	40.0
Stearic Acid	2.5	3.0
Magox OP	4.0	2.4
Whiting	50.0	60.0
Catalpo Clay	50.0	60.0
N550 FEF Black	30.0	20.0
Naugard® 445	2.0	2.0
Sunpar 2280	40.0	40.0
Zinc Oxide	5.0	5.0
Spider Sulfur	0.5	1.0
Diethyl Thiourea	1.0	1.0
Naugex® MBTS	12.0	12.0
Celogen® AZ-130	12.0	12.0
BIK® OT	2.0	2.0
Total	**299.0**	**309.4**
Press Precure: 15 minutes @ 121°C(250°F)		
Oven Normalize: 4 hours @ 93°C(200°F)		
Density, kg/m^3 (lb/ft^3)	192(12)	192(12)

The above compounds are typical 2B1 (RE-41-E1) types. Adjust the cure and blow systems for 2B2 (RE-42-E1) and 2B3 (RE-43-E1).

CELLULAR SHOE SOLING

Uniroyal

	1	2
SBR 8107	100.00	----
Neoprene W	----	100.00
SBR-Styrene MB	30.00	25.00
Picco 100	10.00	----
Stearic Acid	3.00	2.00
Octamine®	1.00	2.00
Magox-OP	----	4.00
Suprex Clay	55.00	50.00
Hi-Sil 233	35.00	40.00
Whiting	15.00	30.00
Zinc Oxide	5.00	5.00
Circosol 4240	10.00	18.00
Carbowax 3350	0.50	----
BIK®-OT	2.00	2.00
Retarder ESEN®	0.75	----
Diethylene GLycol	1.25	----
Naugex® MBTS	1.00	----
DPG	0.25	----
Elasto-O-Sperse PB (DETU)-75	1.25	----
Sulfur	3.00	----
OPEX 80	3.50	3.50
Total	**275.75**	**282.75**
Precure		
Time, min.	12.5	9
Temp., °C	153	168
Expansion Oven		
Time, min.	15	15
Temp., °C	153	153
Test Data		
Shrinkage 12 hours, 100°C, %	1.8	1.2
Specific Gravity	0.52	0.55
Shore A Hardness Skin	60	54
Shore A Hardness Skived	48	41

V.

EPDM

COOLANT HOSE
R.T. Vanderbilt

Nordel 2760P	100.0
Zinc Oxide	5.0
Stearic Acid	1.0
GPF Black (N-650)	100.0
SRF Black (N-762)	100.0
Sunpar 2280	115.0
BUTYL ZIMATE	3.0
METHYL ZIMATE	3.0
Sulfur	0.5
VANAX A	2.0
METHYL TUADS	3.0
Total	432.5
Mooney Scorch, MS 121°C (250°F)	
Minimum Viscosity	24
Time to 10 Pt. Rise, Minutes	23
ODR 160°C(320°F) 12 Minutes(Microdie, 3 Arc, 100 cpm)	
ML, dN.m(in-lb)	0.7(6.0)
MH, dN.m(in-lb)	6.8(60.0)
ts2, Minutes	2.7
t90 Minutes	9.0
Vulcanizate Properties - Press Cure - 177°C(350°F) 10 MIn.	
100% Modulus, MPa (psi)	5.0(730)
Tensile Strength, MPa (psi)	12.0(1750)
Elongation, %	330
Hardness, Shore A	80
Oven Aged 150°C(302°F) 7 Days	
100% Modulus, MPa (psi)	178
Tensile Strength, MPa (psi)	90
Elongation, %	38
Hardness, Points Change	+6
Compression Set - Method B, % (Pellets)	
Cured 15 Min. 177°C(350°F)	
125°C(257°F) 70 Hrs.	34
150°C(302°F) 70 Hrs.	48
Fluids Resistance - Volume Increase	
ASTM #3 Oil - 100°C (212°F) 70 Hrs.	71

AUTOMOTIVE RADIATOR HOSE
R.T. Vanderbilt

Nordel 1145	100.0
Zinc Oxide	5.0
Stearic Acid	1.0
FEF Black (N-550)	120.0
THERMAX FLOFORM (N-990)	100.0
Aromatic Oil	120.0
METHYL ZIMATE	1.25
METHYL TUADS	1.25
ROTAX	0.5
ETHYL TELLURAC	0.8
Sulfur	1.5
Total	451.3
Density, Mg/m^3	1.22
Properties, Cured 15 Minutes at 160°C(320°F)	
100% Modulus, MPa (psi)	2.3(330)
Tensile Strength, MPa (psi)	8.8(1270)
Elongation, %	500
Hardness, Shore A	65

RADIATOR HOSE

DuPont Dow

Nordel IP 5565	100
N550	115
Sunpar 2280	70
Vanox MTI	1
Naugard 445	1
Vulcup 40KE	8
TAIC	4
Total	**299**
Physical Properties – Originals	
Press Cured: 15 minutes @ 160°C	
T-B, psi	2461
E-B, %	190
Shore A, points	63
Compression Set, Method B	
22 hours @ 160°C, %	<5

RADIATOR HOSE

Enichem

DUTRAL TER 4038	80
DUTRAL TER 4033	20
Zinc oxide	10
Stearic acid	1
FEF N550	110
SRF N762	40
Paraffinic oil	85
Escorez 2101	6
CBS	1
TMTDS	1
ZDEDC	3
Sulphur	1.2
Uncured properties	
ML (1+4) @ 100°C	45
MDR @ 180°C	
t2	1'30"
t90	4'06"
Cured properties (30'/160°C)	
T.S., MPa	12
E.B., %	300
M200, MPa	8
Tension set at 200%, %	10
Shore A	67
C. set 70h 100°C, %	45
C. set 70h 125°C, %	55
Aged properties (air oven, 14d/100°C)	
Δ T.S., %	+4
Δ E.B., %	-25
Δ Shore A, points	+4
Aged properties (air oven, 14d/125°C)	
Δ T.S., %	+6
Δ E.B., %	-40
Δ Shore A, points	+6
Aged properties (coolant, 50G/50W, 14d/115°C)	
Δ T.S., %	+2
Δ E.B., %	-25
Δ Shore A, points	+1

SAE J20R, CLASS D-3 SPECIFICATION COOLANT HOSE

Uniroyal

Royalene® 539		70.0
Royalene 563		30.0
N-650 Black		95.0
N-762 Black		80.0
Sunpar 2280		120.0
Zinc Oxide		5.0
Stearic Acid		1.0
Sulfur		0,5
Naugex® SD-1		3.0
Royalac® 136		1.0
Butazate®		4.0
Total		**409.5**
Mooney Viscosity		
ML-1+4 @ 100°C		36
Mooney Scorch @ 125°C		
t3(minutes)		20.9
Rheometer @ 165°C, 1° Arc		
ts2 (minutes)		3.20
t90 (minutes)		9.45
ML (lb-in)		2.54
MH (lb-in)		22.79
Physical Properties, Cured 20 minutes @ 165°C		
		SAE J20R , Class D-3 Spec
Modulus @ 100%, MPa (psi)	2.8(410)	
Tensile, MPa(psi)	10.5(1520)	7.0(1015)min.
Elongation, %	470	300 min.
Hardness, Shore A	72	55-75
Green Strength at R.T.		
Modulus @ 50%, MPa (psi)	0.75(108)	
Tensile, MPa(psi)	3.65(530)	
Elongation, %	795	

SAE J20R, CLASS D-3 SPECIFICATION COOLANT HOSE Continued

Compression Set, ASTM D-395, Method B Plied Specimens, %		
Aged 70 hours @ 125°C	58	75 Max.
Immersion, 50/50 Coolant/Water, 168 hours @ BP, % Change		
Tensile	13	-20 Max.
Elongation	-19	-25 Max.
Hardness (points)	-6	-10 to +10
Volume Swell	0.7	-5 to +20
Heat Aged, ASTM D-375, 168 hours @ 150°C, % Change		
Tensile	2	-35 Max.
Elongation	-60	-65 Max.
Hardness (points)	8	15 Max.

SAE J20R, CLASS D-1 SPECIFICATION COOLANT HOSE

Uniroyal

Royalene® 539	70.0	
Royalene 563	30.0	
N-650 Black	80.0	
N-762 Black	125.0	
Sunpar 2280	140.0	
Zinc Oxide	5.0	
Stearic Acid	1.0	
Sulfur	0.5	
Naugex® SD-1	3.0	
Royalac® 136	1.0	
Butazate®	4.0	
Total	**459.5**	
Mooney Viscosity		
ML-1+4 @ 100°C	31	
Mooney Scorch @ 125°C		
t3 (min)	21.3	
		SAE J20R, Class D-1 Spec.
Rheometer @ 165° C, 1' Arc		
ts2 (min.)	3.39	
t90 (min.)	9.44	
ML (lb-in)	2.27	
MH (lb-in)	19.11	
Physical Properties, Cured 20 Minutes @ 165°C		
Modulus @ 100%, MPa (psi)	2.75(400)	
Tensile, MPa (psi)	9.9(1440)	7.0(1015) min.
Elongation, %	530	300 min.
Hardness, Shore A	69	55-75
Green Strength at R.T.		
Modulus @ 50%, MPa (psi)	0.70(100)	
Tensile, MPa (psi)	3.35(485)	
Elongation, %	830	
Compression Set, ASTM D-395 Method B Plied Specimens, %		
Aged 70 hours @ 125°C	64	75 max.

SAE J20R, CLASS D-1 SPECIFICATION COOLANT HOSE
CONTINUED

Immersion, 50/50 Coolant/Water 168 hours @ BP, % Change		
Tensile	0	-20 max.
Elongation	-19	-50 max.
Hardness (points)	-3	-10 to +10
Volume Swell	2.0	-5 to +20
Heat Aged, ASTM D-375, 168 hours @ 150°C, % Change		
Tensile	18	-20 max.
Elongation	-40	-50 max.
Hardnesss (points)	5	15 max.

AIR BRAKE HOSE

DSM

Keltan 4506	45.00
Keltan P557	75.00
N-650 Black	100.00
Zinc Oxide	5.00
Sunpar 2280	50.00
MBT	2.00
TMTM	1.25
Sulfur	0.50
Total	278.75
Physical Properties	
Specific Gravity	1.11
Compound Viscosity ML (1+4) 100°C	55
Mooney Scorch @ 121°C Min. to 5 Pt. Rise	30+
Press Cure @ 136°C, 45 min. cure	
Tensile, MPa	10.9
Elongation, %	730
300% Modulus, MPa	4.1
Hardness, Shore A	57
Ozone Resistance 100 pphm, 50 Hrs. @ 40°C, 45 min. cure	NC
Low Temperature Brittle Point, °C, 45 min. cure	-57
After Air Oven Aging 45 min. cure, 70 Hrs. @ 177°C	
Tensile, % Change	-33.3
Elongation, % Change	-38.9
Hardness, Points Change	+14

AIR CONDITIONING HOSE COVER COMPOUND

Uniroyal

Royalene 539	50
Royalene 563	50
N-550 Black	110
N-762 Black	115
Sunpar 2280	115
Zinc Oxide	5
Stearic Acid	1
Sulfur	0.5
Tuex®	0.8
Butazate®	2
Naugex® SD-1	2
Sulfads	0.8
Total	**452.1**
Mooney Viscosity	
ML (1+4) @ 100°C	63
Mooney Scorch, MS @ 135°C	
Minimum	24.7
t5, Minutes	10.6
Curemeter @ 160°C, 3° Arc	
ts2 (min)	3.6
tc90 (min)	13.5
ML, dNm (lb-in)	12.7(11.2)
MH, dNm (lb-in)	67.2(59.5)
Press Cured Properties, 20 Minutes @ 160°C(320°F)	
Hardness, Shore A	76
100% Modulus, MPa (psi)	5.4(790)
Tensile Strength, MPa (psi)	12.4(1800)
Elongation, %	240
Compression Set, ASTM D395, Buttons	
70 Hours @ 125°C(257°F)	43
Oven Aged 70 hours @ 150°C(302°F), property changes	
Hardness, points	7
Tensile Strength	-11%
Elongation	-54%

AIR CONDITIONING HOSE COVER COMPOUND
Continued

Oven Aged 168 hours @ 125°C(257°F), property changes	
Hardness, points	9
Tensile Strength	-1%
Elongation	-46%
Immersion, ASTM #3 Oil, 70 hours @ 100°C(212°F), property changes	
Hardness, points	-38
Tensile Strength	-37%
Elongation	-33%
Volume Swell	83%

HYDRAULIC HOSE TUBE FOR PHOSPHATE ESTERS
R.T. Vanderbilt

Nordel 1040	100.0
Stearic Acid	1.0
Zinc Oxide	5.0
ALTAX	1.5
METHYL TUADS	1.0
Sulfur	1.0
GPF-HS(N-650)	46.0
SRF (N-762)	46.0
Sunpar 2280	15.0
Total	216.5
Mooney Scorch, MS 121°C(250°F)	
Minimum Viscosity	34
Time to 5 Pt. Rise, Minutes	36
ODR TM-100 30' @ 157°C(316°F)	
ML, in-lb	14.0
MH, in-lb	82.0
ts2, Minutes	4.7
t90, Minutes	16.0
Stress/Strain Hardness Press Cured 60' @ 157°C(316°F)	
100% Modulus, MPa (psi)	3.6(520)
Tensile Strength, MPa (psi)	13.3(1930)
Elongation, %	410
Hardness, Shore A	72
Fyrquel 220 Immersion 70 Hrs. @ 93°C(200°F)	
100% Modulus, % Retained	147
Tensile Strength, % Retained	104
Elongation, % Retained	76
Hardness, Points Change	-5
Volume Change, %	-1.1
Fyrquel 550 Immersion 70 Hrs. @ 93°C(200°F)	
100% Modulus, % Retained	147
Tensile Strength, % Retained	108
Elongation, % Retained	80
Hardness, Points Change	-6
Volume Change, %	-1.4

HYDRAULIC HOSE TUBE FOR PHOSPHATE ESTERS Continued

Fyrquel GT Immersion 70 Hrs. @ 93°C(200°F)	
100% Modulus, % Retained	119
Tensile Strength, % Retained	107
Elongation, % Retained	90
Hardness, Points Change	-
Volume Change, %	-1.4
Fyrquel T-BEP Immersion 70 Hrs. @ 93°C(200°F)	
100% Modulus, % Retained	130
Tensile Strength, % Retained	102
Elongation, % Retained	78
Hardness, Points Change	-5
Volume Change, %	-1.1
Fyrquel Indol Immersion 70 Hrs. @ 93°C(200°F)	
100% Modulus, % Retained	147
Tensile Strength, % Retained	105
Elongation, % Retained	78
Hardness, Points Change	0
Volume Change, %	-2.6

HIGHLY EXTENDED HOSE
R.T. Vanderbilt

Nordel 2760P	100.0
Zinc Oxide	5.0
Stearic Acid	2.0
Atomite Whiting	200.0
GPF Black (N-650)	200.0
Paraffin	2.0
Circosol 4240	200.0
ALTAX	1.5
BUTYL ZIMATE	2.0
METHYL ZIMATE	1.0
Sulfur	1.0
VANAX A	1.0
METHYL TUADS	
Total	716.5
Mooney Scorch, MS 121°C (250°F)	
Minimum Viscosity	13
Time to 10 Pt. Rise, Minutes	17
ODR 160°C(320°F) 12 Minutes(Microdie, 3 Arc, 100 cpm)	
ML, dN.m(in-lb)	0.3(3.0)
MH, dN.m(in-lb)	3.5(31.0)
ts2, Minutes	3.0
t90 Minutes	9.0
Vulcanizate Properties - Press Cure - 177°C(350°F) 5 Min.	
100% Modulus, MPa (psi)	2.2(310)
Tensile Strength, MPa (psi)	6.4(920)
Elongation, %	460
Hardness, Shore A	70
Oven Aged 125°C(257°F) 7 Days	
100% Modulus, % Retained	248
Tensile Strength, % Retained	115
Elongation, % Retained	44
Hardness, Points Change	+13
Compression Set - Method B, % (Pellets)	
Cured 10 Min. 177°C(350°F)	
100°C(212°F) 70 Hrs.	63
125°C(257°F) 70 Hrs.	68
Fluids Resistance - Volume Increase	
ASTM #3 Oil - 100°C (212°F) 70 Hrs.	91

STEAM HOSE TUBE
R.T. Vanderbilt

Nordel 2522	100.0
AGERITE RESIN D	1.5
Zinc Stearate	1.5
FEF Black (N-550)	55.0
Zinc Oxide	5.0
VANAX MBM	1.0
VAROX DCP-40C	
Total	**170.5**
Mooney Scorch at 132°C (270°F)	
Scorch, T5, Minutes	6.5
Viscosity, ML	39.0
ODR 177°C(350°F) 30 Minutes - M-100	
ML, dN.m(in-lb)	1.1(10.0)
MH, dN.m(in-lb)	10.5(93.0)
tc2, Minutes	0.85'
tc90 Minutes	5.5'
This formulation will age well at 177°C(350°F)	
Cured 8' @ 177°C(350°F)	
Original Properties	
100% Modulus, MPa (psi)	4.9(710)
Tensile, MPa (psi)	13.0(1885)
Elongation, %	190
Hardness, Shore A	74
Appearance After Aging	
Very flexible, very little change in appearance	
Properties After Aging in Steam 7 Days 260°C(500°F) (666 psi)	
100% Modulus, % Retained	53
Tensile, % Retained	55
Elongation, % Retained	0
Hardness, Points Change	-2

STEAM HOSE
R.T. Vanderbilt

	Tube Parts	Cover Parts
Nordel 2744P	100.0	100.0
Zinc Oxide	5.0	10.0
FEF Black (N-550)	100.0	130.0
Low Volatility Paraffinic Oil	60.0	70.0
ETHYL TELLURAC	----	0.8
Sulfur	2.0	0.8
METHYL TUADS	1.5	1.5
ALTAX	1.5	----
CAPTAX	----	2.0
Stearic Acid	----	1.5
Total	**270.0**	**316.6**
	Steam Cured 30'/80 psi	Press Cured 30'/160°C(320°F)
100% Modulus, MPa (psi)	3.8(555)	----
Tensile Strength, MPa (psi)	15.7(2275)	13.4(1950)
Elongation at Break, %	340	320
Hardness, Shore A	71	79
Mooney Scorch, MS 121°C(250°F)		
Minimum	----	21
Minutes to 5 Pt. Rise	----	22
ODR @ 160°C(320°F)		
ML, dN"m(in-lb)	----	1.7(15.5)
MH, dN"m (in-lb)	----	6.4(56.5)
ts2, Minutes	----	3.0
t90, Minutes	----	9.8

NON-BLACK, FLAME-RESISTANT COVER

R.T. Vanderbilt

Nordel 2744P	100.0
Hypalon 40	5.0
Paraffin	3.0
Zinc Oxide	5.0
Stearic Acid	1.0
A-C Polyethylene	3.0
Carbowax 3350	4.0
Hi-Sil 243LD	40.0
TiO_2 R101	10.0
Nucap 200L	80.0
VANTALC 6H	70.0
Yellow Pigment	3.0
Chlorez 700	10.0
Antimony Oxide	10.0
Chlorowax LV	20.0
Sunpar 2280	40.0
Sulfur	2.5
BUTYL ZIMATE	3.0
ZETAX	0.5
Total	410.0
ODR 162°C(324°F) 30 Minutes - LS Mode	
ML, in-lb	13.0
MH, in-lb	74.0
ts2, Minutes	2.25
t90 Minutes	17.5
Original Properties Press Cured 20’ @ 162°C(324°F)	
Tensile, psi	2335
Elongation, %	535
Hardness, Shore A	82
Tear C, pli	191

Extrusion Characteristics

220°F head and die, 180°F barrel,100°F hopper, 130°F screw, warm feed

Notes: Fast extrusion, dull, smooth surface

Flame Resistance

Cured strips of this compound were difficult to ignite, were self-extinguishing in 5 seconds and had o afterglow.

LOW COST, NON-BLACK COVER
R.T. Vanderbilt

Nordel 2744P	100.0
Hypalon 40	5.0
Zinc Oxide	5.0
Paraffin	3.0
Desical P	5.0
Color	As Needed
Carbowax 3350	3.0
Stearic Acid	1.5
DIXIE CLAY	180.0
VANTALC 6H	190.0
Circosol 4240	75.0
Sulfur	2.5
ALTAX	1.5
METHYL TUADS	0.8
BUTYL ZIMATE	1.5
Total	573.8
Specific Gravity	1.6
Mooney Scorch, MS 121°C(250°F)	
Minimum Viscosity	31
Time to 10 Pt. Rise, Minutes	26
Physical Properties - Steam Cure - 30’/80 psi	
Tensile Strength, MPa (psi)	8.8(1275)
Elongation @ Break, %	660
Hardness, Shore A	69

GENERAL PURPOSE HOSE COMPOUND

Union Carbide

ElastoFlo™ MEGA-7265	Value	Typical Value	Test Method
Polymer Composition			**ASTM**
Ethylene	Med-High		D 3900*
ENB	Medium		Internal
Physical Form			
Granular, Average Particle Size, mm	0.8		D 1511*
Product Carbon Black Content			
N-650, phr	23		Internal
Polymer Mooney Viscosity			
ML 1+4 @ 125°C, MU	70		D 1646*
Test Hose Formula			
EPDM Polymer, phr	100.0+X		
Sunpa® 2280, phr	80..0		
N-550 Black, phr	105.0-X		
Calcium Carbonate, phr	65.0		
TE-80, phr	3.0		
Zinc Oxide, phr	5.0		
Stearic Acid, phr	1.0		
Sulfur, phr	0.5		
DTDM, phr	1.0		
DPTT, phr	1.0		
ZDBC, phr	2.0		
ZDMC, phr	2.0		
TMTD, phr	None		
NBC, phr	0.5		
Total	**366.0**		
X=carbon black content of granular form			
Compound Mooney Viscosity			
ML 1+4 @ 100°C, MU	60		D 1646
Mooney Scorch, 135°C			
t(5), min.	2.0		D 1646

*UCC modified

GENERAL PURPOSE HOSE COMPOUND
Continued

MDR Curemeter, 0.5° arc, 182°C			
S'(H), dNm	8.0		D 5289
S'(H)-S'(L), dNm	6.4		D 5289
t(90), min.	1.8		D 5289
Vulcanizate Physicals			
Tensile Strength, MPa	10.6	10.2	D 412
100% Modulus, MPa	3.2		D 412
200% Modulus, MPa	5.8		D 412
300% Modulus, MPa	7.7		D 412
Elongation, %	404	>350	D 412
Hardness, Shore A	64	65	D 2240
Heat Aging Resistance			
7 DAYS @ 135°C			D 573
Tensile Strength, MPa	11.8		D 412
100% Modulus, MPa	5.9		D 412
Elongation, %	206		D 412
Hardness, Shore A	71		D 2240
Loss Strength, %	+12	-18 max.	
Loss Elongation, %	-49	-58 max.	
Hardness Change, Shore A	+9	+12 max.	
Compression Set (22 hr/70°C/25%) %	15	>25	D 395
Compression Set (22 hr/125°C/25%)%	40	<50	D 395

HIGH QUALITY HEAT RESISTANT HOSE

DSM

Keltan P558	60.0
Keltan 7506	60.0
Agerite Resin D	1.0
N-650 Black	130.0
Sunpar 2280	45.0
Zinc Oxide	5.0
Stearic Acid	1.0
TMTD	0.8
DPTH	0.8
ZBDC	2.0
DTDM	2.0
Total	307.6
Physical Properties	
Compound Viscosity, ML (1+4) 100°C	86
Mooney Scorch @ 132°C	
Minutes to 5 Pt. Rise	21.2
Minimum Reading	36
Press Cure @ 170°C	
Tensile, MPa	13.6
Elongation, %	332
Hardness, Shore A	62
Compression Set, %, 24 Hrs. @ 125°C	24.4
After Air Oven Aging 168 Hrs. @ 125°C	
Tensile, % Change	+14.4
Elongation, % Change	-38.6
Hardness, Pts. Change	+8
After Air Oven Aging 1000 Hrs. @ 125°C	
Tensile, % Change	-15.6
Elongation, % Change	-63.4
Hardness, Pts. Change	+13
After Immersion in 50/50 Ethylene Glycol/Distilled Water 168 Hrs. @ 125°C	
Tensile, % Change	+7.5
Elongation, % Change	-18.2
Hardness, Pts. Change	-2
Volume Swell, % Change	+1.9

VACUUM TUBING
DSM

Keltan 5508	100.0
N-650 Black	185.0
Sunpar 2280	125.0
A-C Polyethylene 617	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	1.0
TMTM	1.6
Sulfur	1.5
Total	425.1
Physical Properties	
Specific Gravity	1.23
Compound Viscosity, ML (1+4) 100°C	
Mooney Scorch @ 132°C	
Min. to 3 Pt. Rise	17.2
Minimum Reading	13
Press Cure @ @ 160°C, 20 min. cure	
Tensile, MPa	8.6
Elongation, %	360
300% Modulus, MPa	7.6
Hardness, Shore A	72
Compression Set, %	
22 Hrs. @ 70°C, 30 min. cure	23.4
Low Temperature Brittle Pt., °C, 25 min. cure	-46
Ozone Resistance, 25 min. cure, 100 pphm 70 Hrs. @ 40°C	NC
After Air Oven Aging, 20 min. cure, 70 Hrs. @ 100°C	
Tensile, % Change	nil
Elongation, % Change	-41.7
Hardness, Pts. Change	+3

GARDEN HOSE TUBE COMPOUND

Uniroyal

Royalene® 539	100
N650 Black	150
N762 Black	150
Atomite (Whiting)	200
Calsol 8240 Oil	160
Zinc Oxide	5
Stearic Acid	2
Paraffin Wax	2
MBTS	3
Naugex® SD-1	0.8
Tuex®	0.8
Butazate®	2.5
Sulfur	0.8
Total	**776.9**
Mooney Visosity	
ML (1+4) @ 100°C	54
ML (1+4) @ 132°C	38
Mooney Scorch, MS @ 125°C	
3 pt rise, minutes	8.8
Curemeter @ 160°, 1° Arc	
ML, dN-m(lb-in)	4.5(4.0)
MH, dN-m(lb-in)	28.4(25.1)
ts2, minutes	3.0
tc90, mnutes	7.2
Press Cured Properties, 20’ @ 160°C(320°F)	
Hardness, Shore A	84
100% Modulus, MPa (psi)	4.2(610)
Tensile Strength, MPa (psi)	6.8(980)
Elongation, %	220
Oven Aged 70 hours @ 125°C(257°F), property changes	
Hardness	+3
Tensile Strength	+11
Elongation	-50

GARDEN HOSE TUBE COMPOUND
Continued

Oil Immersion, ASTM #3 Oil	
70 hours @ 100°C(212°F), property changes	
Hardness	-50
Tensile Strength	-18
Elongation	-18
Volume	+74
Compression Set, ASTM D395, Method B Buttons,	
Cured 40 minutes @ 160°C	
70 hours @ 125°C, % Set	70

COVER COMPOUND FOR WIRE BRAID HOSE

Uniroyal

Royalene® 539	100
N-650 Black	55
N-762 Black	30
Hi-Sil 243LD	20
Whiting	20
Sunpar 2280	60
Zinc Oxide	10
Stearic Acid	1
Vanox ZMTI	1.5
Naugard® 445	1.5
Bonding Agent R6	2
Sulfur	2
Sulfads	0.4
Tuex®	0.4
Butazate®	2
Naugex® SD-1	2
Vulklor® 75	1.3
Total	**309.1**
Mooney Viscosity	
ML (1+4) @ °C	69
Mooney Scorch, MS @ 135°C(270°F)	
Minimum	25.8
t3, minutes	7.8
Curemeter @ 190°C(374°F), 1° Arc	
ML, dNm (lb-in)	7.8(6.9)
MH, kn. (lb-in)	44.7(39.6)
ts2, minutes	1.9
t90, minutes	13.3
Physical Properties, Press Cured 20 minutes @ 166°C(330°F)	
Hardness, Shore A	77
100% Modulus, MPa (psi)	2.6(380)
Tensile Strength, MPa (psi)	14.6(2120)
Elongation, %	580
Tear, Die C, kN/m (lb/in)	48.5(277)

COVER COMPOUND FOR WIRE BRAID HOSE Continued

Oven Aged 168 Hours @ 125°C(257°F), property changes	
Hardness, points	+7
Tensile Strength	+15%
Elongation	-59%
Oven Aged 70 Hours @ 150°C(302°F), property changes	
Hardness, points	+9
Tensile Strength, %	+13
Elongation, %	-60
Immersion, ASTM #3 Oil, 70 Hours @ 100°C(212°F) property changes	
Hardness, points	-65
Tensile Strength, %	-64
Elongation, %	-53
Volume, %	+153
Compression Set, Cured 40' @ 160°C(320°F) ASTM D395, Method B, Buttons	
Aged 22 Hours @ 150°C(320°F), % Set	88
Wire Adhesion, kN/m(lb/in)	3.9(22)

HEAT RESISTANT BELT COVER
Uniroyal

Royalene® 580HT	100
Hypalon 40	10
Zinc Oxide	15
N650 Black	60
Sunpar 2280 (Paraffinic Oil)	15
Zinc Stearate	1.5
Naugard® 10	1.5
Vulkanox MB-2/Mg-C	2
Antimony Oxide	10
Wingtack 95	20
Sartomer SR350 (TMPTMA)	2
Poly AC617A	15
Vulcup 40KE	7
Total	**259.0**
Mooney Viscosity	
ML (1+4) @ 100°C	45
Mooney Scorch	
MS @ 132°C, 3 pt rise, mnutes	8.2
Press Cured Properties, 20 minutes @ 171°C(340°F)	
Hardness, Shore A	73
100% Modulus, MPa (psi)	1.7(250)
300% Modulus, MPa (psi)	4.6(670)
Tensile Strength, MPa (psi)	11.3(1640)
Elongation, %	730
Tear, Die C, kN/m (lb/in)	44(250)
Oven Aged 168 hours @ 177°C(350°F), property changes	
Hardness	+13
Tensile Strength	-45%
Elongation	-37%

HIGH TEMPERATURE RESISTANT TRANSMISSION BELT
R.T. Vanderbilt

	Cover	Friction & Skim
Nordel 1040	80.0	----
Hypalon 40	20.0	----
Natural Rubber, Grade 5	----	100.0
VANPLAST R	----	2.0
Stearic Acid	----	1.0
Zinc Oxide	2.0	5.0
AGERITE RESIN D	1.0	1.5
AGERITE HP-S	----	0.5
Pine Tar	----	5.0
Ground Calcium Carbonate	----	15.0
VAROX DCP-40C	7.0	----
HAF Black (N-330)	55.0	----
Sartomer SR-350	1.5	----
Sunpar 2280	7.0	----
Sulfur	----	3.0
AMAX	----	1.0
Total	173.5	134.0
Density, Mg/m^3	1.11	1.05
Properties, Cured 20 Minutes at 157°C(315°F)		
300% Modulus, MPa (psi)	6.9(1000)	1.4(200)
Tensile Strength, MPa (psi)	13.8(2000)	15.2(2200)
Elongation, %	550	750
Hardness, Shore A	60	40
Mooney at 121°C(250°F)		
Scorch, t5, minutes	20	38
Plasticity, ML	63	30

AUTOMOTIVE WINDOW GASKETS
DSM

	1	**2**	**3**	**4**
Keltan 5251A	115.0	115.0	115.0	115.0
Neoprene WHV	---	5.0	---	---
Copo 1500	---	---	5.0	---
RICON 130P	---	---	---	5.0
N-550 FEF Black	50.0	50.0	50.0	50.0
N-765 SRF-HS Black	100.0	100.0	100.0	100.0
Whiting	33.0	33.0	33.0	33.0
Mistron Vapor	33.0	33.0	33.0	33.0
Sunthene 255	87.0	87.0	87.0	87.0
Desical P	10.0	10.0	10.0	10.0
Sulfur	1.7	1.7	1.7	1.7
MBTS	1.0	1.0	1.0	1.0
DTDM	1.0	1.0	1.0	1.0
TMTM	0.4	0.4	0.4	0.4
BiMDC	0.4	0.4	0.4	0.4
Total	432.5	437.5	437.5	437.5
Physical Properties				
Compound Viscosity				
ML (1+4) 100°C	31	32	30	29
Mooney Scorch @ 132°C				
Min. to 5 Pt. Rise	6	7	6	6
Minimum Reading	13	13	12	12
Rheometer Properties, Model 100, 176°C				
M_L, dN-m	4	5	5	4
M_H, dN-m7071	4	8	6	5
ts2, minutes	0.8	0.9	0.8	0.9
t'c(90), minutes	4.8	4.2	2.1	3.9
Press Cure @ 176 °C, 12 min. cure				
Tensile, MPa	11.7	11.2	11.3	11.1
Elongation, %	251	246	317	249
100% Modulus, MPa	6.4	6.4	5.4	6.5
200% Modulus, MPa	9.9	9.8	8.1	9.8
Hardness, Shore A	69	70	68	67

AUTOMOTIVE WINDOW GASKETS
Continued

Press Cure @ 176 °C, 15 min. cure				
Tensile, MPa	11.5	11.1	10.6	11.0
Elongation, %	235	229	286	241
100% Modulus, MPa	6.7	6.5	5.3	6.4
200% Modulus, MPa	10.5	10.0	8.2	9.6
Hardness, Shore A	68	71	71	70

WINDSHIELD GASKETS
DSM

	1	2	3
Keltan 5508	100.0	100.0	100.0
N-650 Black	155.0	200.0	185.0
Sunpar 2280	115.0	155.0	120.0
Paraffin Wax	5.0	5.0	5.0
Zinc Oxide	5.0	5.0	5.0
Stearic Acid	1.0	1.0	1.0
MBTS	1.3	1.3	1.3
TMTD	0.6	0.6	0.6
ZBDC	2.0	2.0	2.0
Sulfur	1.5	1.5	1.5
Total	386.4	471.4	421.4
Physical Properties			
Specific Gravity	1.19	1.23	1.24
Compound Viscosity			
ML (1+4)100°C	38	52	68
Mooney Scorch @ 132°C			
Min. to 3 Pt. Rise	9.5	11.5	9.0
Minimum Reading	22	28	34
Press Cure @ 160°C, 20 min. cure			
Tensile, MPa	10.3	9.3	9.3
Elongation, %	500	570	430
300% Modulus, MPa	7.6	5.2	7.2
Hardness, Shore A	54	59	68
Compression Set, %			
22 Hrs. @ 70°C, 30 min. cure	22.0	27.3	19.5
Low Temperature			
Brittle Pt., °C, 20 min. cure	-48	-48	-48
Ozone Resistance, 70 Hrs. @ 40°C			
100 pphm	NC	NC	NC
NC = No cracking			
After Air Oven Aging, 70 Hrs. @ 100°C, 20 Min. Cure			
Tensile, % Change	-6.6	-14.7	nil
Elongation, % Change	-28.8	-42.2	-37.3
Hardness, Pts. Change	+4	+6	+3

AUTOMOTIVE WEATHERSTRIPS
Uniroyal

Masterbatch	
Royalene 525	100.0
Catalpo Clay	35.0
SL-90 Black	40.0
N550 FEF Black	35.0
York Whiting	50.0
Zinc Oxide	4.0
Stearic Acid	1.0
Circosol 4240	60.0
Celogen® AZ-130	8.0
Total	**333.0**

Mixing Procedure
#2 Banbury
0 min. ingredients then Royalene EPDM
Drop 132°C(270°F) (5-6 min.)

Masterbatch	333.0
BIK®-OT	1.0
Naugex® MBT	2.0
Tellurac	1.0
Butazate® Powder	2.0
Sulfads	2.0
Sulfur	2.0
Total	**343.0**

Mixing Procedure
#2 Banbury
0 min. ½ MB, ingredients plus ½ MB
Drop 82°C(180°F) (2-3 min.)

Mooney Scorch @ 125°C(257°F) min.	3.5
Mooney Viscosity ML-4 @ 100°C(212°F)	42
Rheometer Data @ 177°C(350°F) ts2 min.	0.85

Recommended Curing Conditions
Precure 3 min. 154°C(310°F)
Expansion 3 min. 200°C(392°F)

Expanded Density, lbs.ft^3	17
kg/m^3	272

EPDM SEAL
R.T. Vanderbilt

Nordel 1040	100.0
Zinc Oxide	5.0
Stearic Acid	1.0
FEF Black (N-550)	45.0
AGERITE RESIN D	2.0
Spider Sulfur	0.25
VAROX DCP-40C	9.0
Total	162.25
Physical Properties	
Tensile, MPa (psi)	14.4(2100)
100% Modulus, MPa (psi)	2.4(350)
Elongation, %	380
Hardness, Shore A	68

GENERAL GASKET
DuPont Dow

NDX 4570	100.00
N550	50.00
Mistron Vapor	30.00
Sunpar 2280	40.00
Zinc Oxide	3.00
Stearic Acid	1.00
MBT	1.00
TMTD	0.80
Sulfur	1.00
Ethyl Zimate	1.30
Butyl Zimate	2.00
Total	**230.10**
Mooney ML 1+4 @ 100°C	
Initial	74.3
ML 1+4	50.7
Mooney ML 1+4 @ 125°C	
Initial	35.5
ML 1+4	19.5
ODR @ 160°C, 3° Arc, 30 minute chart	
M-L (in-lbs)	9.5
Ts-2 (minutes)	1.9
Tc-90 (minutes)	11.3
M-H (in-lbs)	67.5
Physical Properties – Originals	
Press Cured: 16 minutes @ 160°C	
M-50, psi (MPa)	210(1.45)
M-100, psi (MPa)	342(2.36)
T-B, psi (MPa)	1543(10.64)
E-B, %	466
Shore A, points	60

GENERAL GASKET
Continued

Physical Properties – Heat Aged 70 Hours @ 125°C	
Press Cured: 16 minutes @ 160°C	
M-50, psi	315
(% Change, M-50)	50
T-B, psi	1550
(% Change, T-B)	0
E-B, %	310
(% Change, E-B)	-33
Shore A, points	64
(Points Change)	4
Compression Set, Method B	
22 Hours @ 100°C, %	38

WASHING MACHINE GASKET
Enichem

DUTRAL TER 6235	87.5	
DUTRAL TER 4334	42	
Anox HB	0.1	
Zinc oxide	4	
Stearic acid	1	
Polyplastol 4	1	
A-189	0.5	
Glicogum 4000	1	
Ultrasil VN-2	40	
Whitetex	40	
Rutile titanium dioxide	10	
Paraffinic oil	40	
MBT	1.5	
ZDBDC	2.5	
TDEDC	1	
TMTDS	1	
Sulphur	0.8	
Mix CaO-75	3	
Uncured properties		
Mooney viscosity [ML (1+4) @ 100°C]	54	
Cured properties	**20’ at 160°C**	**120” at 175°C**
T.S., MPa	12	14
E.B., %	560	770
M 100, MPa	1.5	1.5
M 200, MPa	3	2
M 300, MPa	5	3
Tension set, at 200%	6	8
Tear strength (B), N/mm	34	40
Shore A	52	49
C. set, 70h/100°C, %	51	
Aged properties (2% sodium hypochlorite)*		**24 hours at 70°C**
Δ T.S., %	-25	+12
Δ E.B., %	-10	-3.2
Δ Shore A	-3	-2
Δ Volume, %	+4.6	+9.6
Δ Weight, %	+4.2	+8.6

WASHING MACHINE GASKET
Continued

(1 % Detergent)*	**96 hours at 100°C***	
Δ T.S., %	-8.0	-2.3
Δ E.B., %	-8.0	-23
Δ Shore A	-3.0	-1
Δ Volume, %	+3.9	+8.8
Δ Weight, %	+4.8	+7.8
(Hot air oven)	**72 hours at 100°C**	
Δ T.S., %	+1.6	-4.3
Δ E.B., %	-12.0	-30
Δ Shore A	+2	+8
Δ Volume, %	-0.7	-1.3
Δ Weight, %	-1.1	-1.3
(Olive oil)*	**24 hours at 80°C**	
Δ T.S., %	-33	-30
Δ E.B., %	-29	-10
Δ Shore A	-8	-12
Δ Volume, %	+12	+16
Δ Weight, %	+14	+19

* = Change of solution every 24 hours.

CHLORAMINE RESISTANT COMPOUND
For Molded Gaskets, Seals, Membranes
Uniroyal

Royalene® 580HT	100
N650 Black	40
Mistron Vapor CB	25
Sunpar 2280 Oil	15
Zinc Oxide	5
Naugard® Q	2
SR 350 (TMPTMA)	2
Dicup 40KE	7
Total	**196**
Mooney Viscvosity	
ML (1+4) @ 100°C	65
Mooney Scorch, MS @ 135°C	
3 pt rise, minutes	6.2
Curemeter @ 176°C, 1° Arc	
ML, dN-m(lb-in)	6.1(5.4)
MH, dN-m(lb-in)	39.7(35.2)
ts1, minutes	0.8
tc90, minutes	5.7
Press Cured Properties, 10 minutes @ 176°C	
Hardness, Shore A	64
300% Modulus, MPa (psi)	7.0(1020)
Tensile Strength, MPa (psi)	6.8(1835)
Elongation, %	460
Tear, Die C, kN/m(lb/in)	41(230)
Compression Set, ASTM D395, Method B Buttons	
Cured 20 Mintues @ 176°C	
70 hours @ 125°C, % Set	21
Immersion in Chloramines, 60 ppm at 60°C, %	**Volume Change**
30 Days	4.4
69 Days	11.3

BUILDING SEALS
DSM

Keltan 70A	50.00
Keltan 5508	50.00
N550 Black	100.00
Sunpar 2280	45.00
Zinc Oxide	5.00
Stearic Acid	1.00
MBT	0.75
TMTM	2.00
Sulfur	1.00
Total	254.75
Physical Properties	
Specific Gravity	1.10
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	30+
Minimum Reading	45
Press Cure @ 160°C, 15 min. cure	
Tensile, MPa	15.7
Elongation, %	390
300% Modulus, MPa	13.1
Hardness, Shore A	80
Low Temperature Brittle Point, °C	
15 min. cure	-57
Compression Set, %	
70 Hrs. @ 100°C	27.0
After Immersion in Water, 20 min. cure, 7 days @ 70°C	
Weight, % Change	+7.3
Elongation, % Change	-50
Hardness, Points Change	+1

CURTAIN WALL SEAL
DSM

Keltan P557	105.00
Keltan 5508	30.00
N-550 Black	85.00
Sunpar 2280	55.00
Zinc Oxide	5.00
Stearic Acid	1.00
MBT	0.75
TMTM	2.00
Sulfur	1.00
Total	284.75
Physical Properties	
Specific Gravity	1.20
Compound Viscosity	
ML (1+4) 100°C	62
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	30+
Press Cure @ 160°C, 15 min. cure	
Tensile, MPa	13.6
Elongation, %	580
300% Modulus, MPa	5.7
Hardness, Shore A	60
Compression Set, %	
22 Hrs. @ 70°C, 30 min. cure	11.6
22 Hrs. @ 100°C, 30 min. cure	23.2
Low Temperature	
Brittle Point, °C, 20 min. cure	Passed
Ozone Resistance	
70 Hrs. @ 40°C, 20 min. cure, 100 pphm	NC
After Air Oven Aging	
70 Hrs. @ 100°C, 15 min. cure	
Tensile, % Change	-26.6
Elongation, % Change	-39.7
Hardness, Pts. Change	+1

LATHE CUT WASHER
DSM

Keltan 7506	100.0
Hard Clay	150.0
Whitetex	75.0
Silene 732D	30.0
Sunpar 150	30.0
A-C Polyethylene 617A	10.0
Cumar R-16	10.0
Paraffin Wax	3.0
Zinc Oxide	5.0
Stearic Acid	1.0
Diethylene Gycol	2.0
MBT	0.8
DPTH	0.8
TMTD	1.4
Sulfur	1.5
Total	420.5
Physical Properties	
Specific Gravity	1.51
Mooney Scorch @ 132°C, Min. to 3 Pt. Rise	14.5
Minimum Reading	51
Press Cure @ 160°C, 20 min. cure	
Tensile, MPa	7.6
Elongation, %	670
300% Modulus, MPa	4.1
Hardness, Shore A	79
Low Temperature	
Brittle Point, °C, 30 min. cure	-48

GENERAL WEATHER-STRIPPING
DuPont Dow

NDR 5750P	100.00
N650	100.00
N762	100.00
Desical P	8.00
Sunpar 2280	115.00
Zinc Oxide	5.00
Stearic Acid	1.00
Butyl Zimate	1.50
Ethyl Tellurac	0.50
MBT	2.00
TMTD	0.80
Sulfur	1.50
Total	**435.30**
Mooney ML 1+4 @ 100°C	
Initial	46.5
ML 1+4	39.6
Physical Properties (RT)	
Press Cured: 15 minutes @ 160°C	
M-50, psi (MPa)	319(2.20)
M-100, psi (MPa)	652(4.50)
T-B, psi (MPa)	1623(11.19)
E-B, %	330
Shore A, points	74
Physical Properties – After Aging 70 hours @ 125°C	
M-50, psi	557.8
(% Change, M-50)	74.6
T-B, psi	2010
(% Change, T-B)	23.8
E-B, %	156.3
(% Change, E-B)	-52.6
Shore A, points	79
(Points Change)	5.0

GENERAL WEATHER-STRIPPING
Continued

Tear Strength	
Die C, ppi	220
Braebender Extrusion	
Average Length, inch	16.83
Average Weight, grams	22.3
Weight/Unit Length, grams/inch	1.33

LINESMAN BLANKET CALENDERING COMPOUND
DSM

Keltan P558, P Grade	75.0
Keltan 40A	50.0
Hi-Sil 233	55.0
Harwick DSC-18	1.4
Sunpar 2280	65.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	2.0
DTDM	1.5
DPTH	0.5
TMTD	0.75
PEG 3350	2.0
Sulfur	0.75
Total	259.9
Physical Properties	
Compound Viscosity ML (1+4) 100°C	51
Mooney Scorch @ 121°C	
Minutes to 5 Pt. Rise	20.7
Minimum Reading	19
Press Cure @ 160°C	
Tensile, MPa	15.6
Elongation, %	791
200% Modulus, MPa	1.70
300% Modulus, MPa	2.50
Hardness, Shore A	45

UV RESISTANT WHITE SHEET

DSM

Keltan 5508	60.0
Keltan 4506	40.0
Sunpar 150LW	75.0
Hi-Sil EP	80.0
Hi-Sil 233	10.0
Silane A189	1.5
Agerite Superlite	1.5
Titanium Dioxide	30.0
Protox 169	10.0
Stearic Acid	1.0
MOTS #1	2.0
ZBDC	3.0
TMTD	1.0
DTDM	1.34
Sulfur	0.5
Total	316.84
Physical Properties	
Compound Viscosity, ML (1+4) 100°C	49
Mooney Scorch @ 121°C	
Min. to 3 Pt. Rise	13
Minimum Reading	8
Rheograph Properties, Model 100 182°C	
M_L Torque, dN*m	23
M_H Torque, dN*m	65
t2, minutes	1.6
tc'90, minutes	6.8
Press Cure @ 182°C	
Tensile, MPa	12.8
Elongation, %	660
100% Modulus, MPa	2.00
300% Modulus, MPa	6.21
Hardness, Shore A	56
Tear Die C, kN/m	43.9
Ultraviolet Discoloration, ASTM D11 48-70	
48 Hrs. Exposure	No Change

ROOF SHEETING
Enichem

DUTRAL TER 4048	75
DUTRAL TER 4028	25
Zinc oxide	10
Stearic acid	1
FEF N550	80
Kamig (soft clay)	65
Aktisil. VM	20
Vaseline oil	20
Paraffinic oil	65
Anox HB	0.5
MMBI	2
Si 69	1
MBT	1
ZDBDC	2.5
TMTDS	2.5
End 75	0.7
Uncured properties	
ML (1+4) @ 100°C	56
Monsanto ODR @ 170°C	
t2	1’56”
t90	6’19”
Cured properties (by steam at 170°C)	
T.S., MPa	10
E.B., %	500
M100, MPa	3.5
M300, MPa	7
Tension set at 100%, %	10
Shore A	62
Tear resistance, N/mm	44
Aged properties (7d/121°C)	
T.S., MPa	12
E.B., %	350
Shore A	66
Tear resistance, N/mm	38

ROOF SHEETING
Continued

Aged properties (7d/135°C)	
T.S., MPa	12.5
E.B., %	300
Shore A	67
Tear resistance, N/mm	35

SINGLE PLY ROOFING COMPOUND
Union Carbide

ElastoFlo™ MEGA-6322	Value	EPDM Roofing Requirements ASTM D 4637	Test Method
Polymer Composition			**ASTM**
Ethylene	Medium		D 3900*
ENB	Low		Internal
Physical Form			
Granular, Average Particle Size, mm	0.8		D 1511*
Product Carbon Black Content			
N-650, phr	22		Intenal
Polymer Mooney Viscosity			
ML 1+4 @ 125°C, MU	65		D 1646*
Test Roofing Formula			
EPDM Polymer, phr	100.0 + X		
Sunpar® 2280, phr	80.0		
N-650 Black, phr	120.0-X		
Dixie Clay®, phr	20.0		
Zinc Oxide, phr	5.0		
Stearic Acid, phr	1.0		
TMTD, phr	1.0		
MBT, phr	1.0		
MBTS, phr	1.0		
Sulfur, phr	1.0		
Total	**330.0**		
X=carbon black content of granular form			
Compound Mooney Viscosity			
ML 1+4 @ 100°C, MU	73		D 1646
Mooney Scorch			
t(5) @ 135°C, min.	6.3		D 1646
MDR Curemeter, 0.5° arc, 175°C			
S'(H), dNm	13.1		D 5289
S'(H)-S'(L), dNm	11.2		D 5289
t(90), min.	6.5		D 5289

*UCC modified

FLAME RETARDANT, SHEETING OR MOLDING APPLICATIONS

Uniroyal

Royalene® 512	100.0
Decabromodiphenyloxide	30.0
Antimony Oxide	10.0
N347 Black	80.0
Talc	50.0
Paraffinic Oil	60.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	2.2
Tuex®	0.7
Ethyl Tuex®	0.7
Sulfur	0.75
Total	**340.35**
Mooney Viscosity	
ML (1+4) @ 100°C	60
Curemeter @ 150°C, 1° Arc, 1.7 Hz	
tc90, minutes	30.0
Steam Wrap Cure, 3 hours/0.4 MPa (60 psi) steam	
Unaged	
Hardness, Shore A	73
200% Modulus, MPa (psi)	6.3(920)
Tensile Strength, MPa (psi)	16.5(2400)
Elongation, %	440
Tear, Die C, kN/m (lb/in)	36.7(210)
Oven Aged 7 Days @ 125°C(257°F)	
Tensile Strength, % Change	+2
Elongation, % Change	-28
Oxygen Index	26.5
Flame Spread, 30° Incline Burn*	
Sample self-extinguished 15 seconds after removal of flame	

*Flame applied to lower edge of sample for 60 seconds.
Note: The flame spread ratings are not intended to reflect hazards presented by these or other materials under actual fire conditions.

MOTOR LEAD WIRE INSULATION
DSM

Keltan 4506	50.0
Keltan 5508	50.0
Nulok 321	100.0
Sunpar 2280	30.0
Paraffin Wax	10.0
A-C Polyethylene 617A	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
TMTM	1.0
CBS	1.0
MBT	1.0
Sulfur	1.5
Total	255.5
Physical Properties	
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	11
Minimum Reading	29
Press Cure @ 160°C, 15 min. cure	
Tensile, MPa	15.3
Elongation, %	650
300% Modulus, MPa	5.5
Hardness, Shore A	60
After Aging in Water, 70 Hrs. @ 82.2°C, 5 min. cure	
Weight, % Change	+1.13
Volume, % Change	+1.0
Hardness, Pts. Change	+2
After Air Oven Aging, 70 Hrs. @ 150°C, 15 min. cure	
Tensile, % Change	-15.7
Elongation, % Change	-60
Hardness, Pts. Change	+10
After Air Oven Aging, 10 days @ 136°C, 15 min. cure	
Tensile, % Change	1.1
Elongation, % Change	-48
Hardness, Pts. Change	+10

IGNITION CABLE INSULATION

DSM

Keltan 4506	100.0
Silene 732D	100.0
Sunpar 2280	20.0
Paraffin Wax	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	1.6
TMTD	1.2
DPTH	0.8
Sulfur	1.0
Total	235.6
Physical Properties	
Specific Gravity	1.18
Compound Viscosity, ML (1+4) 100°C	88
Mooney Scorch @ 132°C	
Min. to 3 Pt. Rise	5.5
Minimum Reading	34
Press Cure @ 160°C, 10 min. cure	
Tensile, MPa	10.3
Elongation, %	770
300% Modulus, MPa	3.5
Hardness, Shore A	65
Compression Set, %	
22 Hrs. @ 70°C, 20 min. cure	40.6
Ozone Resistance, 100 pphm	
70 Hrs. @ 40°C, 15 min. cure	NC
Low Temperature Brittle Point, °C, 15 min. cure	-54
Steam Cure @ 160°C, 10 min. cure	
Tensile, MPa	11.0
Elongation, %	770
Hardness, Shore A	64

IGNITION WIRE INSULATION
DSM

Keltan 4506	50.0
Keltan 5508	50.0
Silene 732D	100.0
Sunpar 2280	30.0
Paraffin Wax	1.5
Zinc Oxide	3.0
Stearic Acid	1.0
TMTD	1.5
ZMDC	1.0
MBT	1.0
Sulfur	1.25
Total	240.25
Physical Properties	
Specific Gravity	1.17
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	13
Minimum Reading	40
Press Cure @ 160°C, 15 min. cure	
Tensile, MPa	10.0
Elongation, %	660
300% Modulus, MPa	4.5
Hardness, Shore A	64
After Immersion in Water 70 Hrs. @ 82°C, 15 min. cure	
Durometer, Pts. Change	+1
Weight, % Change	6
Volume, % Change	4.5
After Aging 10 days @ 158°C, 15 min. cure	
Tensile, % Change	+32.8
Elongation, % Change	-66.7
Hardness, Pts. Change	12
After Aging 70 Hrs. @ 149°C, 15 min. cure	
Tensile, % Change	+31.0
Elongation, % Change	-62.0
Hardness, Pts. Change	+11

IGNITION WIRE INSULATION
Continued

Steam Cure @ 160°C, 15 min. cure	
Tensile, MPa	11.4
Elongation, %	850
300% Modulus, MPa	3.5
Hardness, Shore A	64
After Aging 70 Hrs. @ 149°C, 15 min. cure	
Tensile, % Change	+14.9
Elongation, % Change	-74.0
Hardness, Pts. Change	+13

LOW COST ELECTRICAL INSULATION
DSM

Keltan 5508	100.0
Silene D	75.0
Nucap 200	75.0
Burgess KE	75.0
Circosol 4240	90.0
Carbowax 4000	1.5
Stearic Acid	1.0
TE-80	3.0
Zinc Oxide	5.0
TMTD	3.0
ZBDC	2.25
TMTM	1.5
DTDM	2.0
Sulfur	0.6
Total	434.85
Physical Properties	
Compound Viscosity, ML (1+4) 100°C	56
Mooney Scorch MS @ 132°C	
Minutes to 5 pt. rise	8.5
Minimum Reading	21
Press Cure @ 160°C	
Tensile, MPa	8.28
Elongation, %	670
100% Modulus, MPa	2.07
200% Modulus, MPa	2.93
Hardness, Shore A	66
Compression Set, %	
70 Hrs. @ 100°C	37.3
70 Hrs. @ 100°C	60.7
After Air Oven Aging, 70 Hrs. @ 121°C	
Tensile, % Change	-2.1
Elongation, % Change	-13.5
Hardness, Pts. Change	+8
After Immersion in ASTM #3 Oil, 70 Hrs. @ 100°C	
Volume Change, %	87.7

MEDIUM-HIGH VOLTAGE INSULATION

Enichem

DUTRAL CT 053	100
LPDE (MI=20)	10
Zinc oxide	5
ERD-90	5
Whitetex	45
Paraffinic wax	5
Anox HB	1.5
A-172	1
Lithene AH	6
Peroximon F/40	6
Uncured properties	
ML (1+4) @ 100°C	40
Monsanto ODR @ 180°C	
t2	1’39”
t90	9’54”
Cured properties (40’/165°C)	
T.S., Mpa	7.5
E.B., %	270
M200, MPa	5.5
Shore A	68
Aged properties (7d/150°C)	
T.S., % retained	103
E.B., % retained	102
Water absorption (at 100°C)	
after 1 day, mg/cm^2	0.22
after 14 days, mg/cm^2	0.45
Electrical properties*	
Power factor at 12Kv (Eo), %	0.31
Power factor at 24Kv (2 Eo), %	0.33
Insulation resistance, Mohm. Km	7000
S.I.C.	2.8
Partial discharge at 15Kv (1.25 Eo), pc	1
Impulse test at 125 Kv	pass
High voltage time test 40 Kv/4 hours	pass

* Carried out on steam cured cable (12Kv).
Copper tinned wire = 1x95 mm 2;
insul. thickness = 6.5 mm; semic. thick = 0.5mm.

FLEXIBLE CORD INSULATION
Uniroyal

Royalene X3751	100
Whitetex Clay	180
Naugard® Q	1
Sunpar 2280	55
Paraffin Wax	5
Vinyl Silane A-172	2
Kadox 911C	5
SR-350	2
Vulcup 40KE	7.5
Total	**357.5**
Mooney Viscosity	
ML (1+4) @ 100°C	53
Mooney Scorch, MS @ 125°C	
Minimum	20
3 pt rise, minutes	11
Curemeter @ 165°C, 3° Arc	
ML, dN-m (lb-in)	9.5(8.4)
MH, dN-m(lb-in)	81(72)
ts2, minutes	1.5
tc50, minutes	10.1
tc90, minutes	24.3
Physical Properties (#14 AWG solid copper, 30 mil wall, steam cured 1.5' @ 220 psig steam)	
200% Modulus, MPa (psi)	10.8(1560)
Tensile Strength, MPa (psi)	13.0(1890)
Elongation, %	220*
Oven Aged 7 Days @ 136°C	
Tensile Strength, MPa (psi)	13.6(1970)
% Change	+5
Elongation, %	190
% Change	-14

*The specification calls for 250% minimum elongation; increasing the Sunpar 2280 level to 65 phr will increase the elongation above the minimum without significantly affecting other properties.

FLEXIBLE CORD INSULATION
Continued

SIC, PF @ 75°C Water

	SIC @ 80 v/mil	PF @ 80 v/mil	PF @ 40v/mil
1 Day	3.23	1.6	1.6
7 Days	3.21	1.7	1.6
14 Days	3.22	1.5	1.5
Capacitance change			
7-14 days, %			0.3
1-14 days, %			-0.3
Stability Factor			
1 day/14 days/ Change, 1-14 days			0.0/0.0/0.0
Insulation Resistance - MΩ@1000 ft (MΩ/km)			
RT Water: 1 day			23000(7012)
75°C Water:			
1 day			635(194)
Week 1			721(220)
Week 2			614(187)
Week 3			695(212)
Week 4			690(210)
Week 5			691(211)
Week 6			696(212)
Week 7			699(213)
Week 8			818(249)
Week 9			931(284)
Week 10			838(255)
Week 12			687(209)
Week 13			830(253)
Week 14			828(252)
Week 15			792(241)
Week 16			816(249)
Week 17			794(242)
Week 18			744(227)
Week 19			773(236)
Week 20			753(230)
Week 21			865(264)
Week 22			840(256)
Week 23			645(197)
Week 24			729(222)

EPDM HEAVY DUTY JACKET (ASTM D752)
Englehard

		Specification
Vistalon 3708	100.00	
Zinc Oxide	5.00	
BUCA Kaolin	110.00	
FEF Black	40.00	
Sunpar 2280	45.00	
Microcrystalline Wax (175°F,m.p.)	5.00	
A-174 Silane	0.50	
Sulfur	1.00	
TMTDS	0.80	
TDEDC (80%)	0.80	
DPTTS	0.80	
MBTS	1.50	
Vocol S	3.00	
Specific Gravity	1.28	
Processability		
Mooney Scorch @ 121°C, (MS)		
t3, minutes	9	
t5, minutes	11	
Mooney Plasticity @ 121°C, (MS)		
Minimum Reading	25	
Physical Properties		
Steam Cured 60 Seconds @ 225 psi		
Hardness, Shore A	70	---
200% Modulus, psi	570	500
Tensile Strength, psi	2120	1800
Elongation, %	625	300
Maximum Set (IPCEA 4.13.3), in.	35/64	3/8(20%)
Aged Physical Properties		
Air Bomb Aged 20 Hours @ 127°C		
Tensile Strength Retained, %	90	50
Elongation Retained, %	59	50

EPDM HEAVY DUTY JACKET (ASTM D752)
Continued

Oxygen Bomb Aged 168 Hours @ 80°C		
Tensile Strength Retained, %	101	50
Elongation Retained, %	74	50
Air Oven Aged 168 Hours @ 100°C		
Tensile Strength Retained, %	91	50
Elongation Retained, %	57	50
Oil Resistance		
18 Hours Immersion @ 127°C in ASTM Oil No. 2		
Tensile Strength Retained, %	40	60
Elongation Retained, %	70	60
Weight Gain, %	97	---
Electrical Properties		
Specific Surface Resistivity, megohms	1.3×10^6	2×10^5

FLEXIBLE CORD INSULATION
Recommended for 90°C service
Englehard

Epsyn 40-A (EPDM)	100.0
Hard Clay	150.0
Satintone W	50.0
Naphthenic Oil	50.0
Paraffinic Wax	10.0
Low Molecular Weight Polyethylene	5.0
Stearic Acid	1.0
Zinc Oxide	5.0
MBTS	0.2
Sulfur	1.5
TDTDS	1.0
Santocure NS	1.8
Viscosity @ 150°F, ML:	
Minimum Reading	31
Mins. to 5 Pt. Rise	14.5

	Steam Cure @ 320°F, 75 psi Pressure	Initial	After Oven Aging: 70 Hrs.@ 121°C	After Oven Aging: 70 Hrs.@ 149°C
Tensile, psi	3’	1250	1200	1400
	5’	1300	1150	1400
	10’	1300	1100	1300
Elongation, %	3’	730	350	220
	5’	680	380	210
	10’	630	300	200
300% Modulus, psi	3’	475	1000	----
	5’	525	975	----
	10’	575	950	----
Hardness, Shore A	3’	66	74	76
	5’	67	74	75
	10’	68	74	78

FLEXIBLE CORD INSULATION
Continued

Steam Cure @ 320°F, 75 psi Pressure	Initial	After Oven Aging 70 Hrs.@ 121°C	After Oven Aging 70 Hrs.@ 149°C
UL Recovery-Set After 2 mins. @ 150% Elongation, Inches	0.25	----	----
Low Temp. Flex. @ -67°F	Flexible	----	----
Ozone (70 Hrs./100F/100 pphm)	No Cracks	----	----
Specific Gravity	1.38		
Flexible Cord Insulation			
After 168 Hrs. in Oxygen Bomb, 80°C, 300 Lbs. Oxygen			
Tensile, % of Original	101		
Elongation, % of Original	81		
After 42 Hrs. in Air Bomb, 127°C, 80 Lbs. Air			
Tensile, % of Original	83		
Elongation, % of Original	75		

MEDIUM VOLTAGE (15 KV) INSULATION
Englehard

Ingredients	% By Weight	phr
Epcar 545 EPDM	37.63	100.00
Zinc Oxide	1.88	5.00
Agerite MA	0.55	1.47
Translink 37	45.41	120.69
Red Lead Dispersion	1.88	5.00
Vinyl Silane A-172	0.39	1.03
Paraffin Wax	1.88	5.00
Sunpar 2280 Oil	7.53	20.00
Di-Cup 40 KE Peroxide	2.85	7.59
Total	**100.00**	**265.78**
Specific Gravity, calculated	1.33	
Polymer by Volume	58.97%	

Physical Properties

	Completed Cable	Required AE1C #6
Insulation Original Properties		
Tensile Strength, MPa(psi)	8.8(1277)	4.8(700) min.
Elongation, %	337	250 min.
Air Oven Aged, 7 days @ 121°C		
Tensile Retention	101	75 min.
Elongation, %	92	75 min.
Air Bomb Aged, 42 hrs @ 127°C		
Tensile Retention	102	80 min.
Elongation, %	96	80 min.
Heat Distortion, 1 hr. @ 121°C	2	10 max.
Hot Modulus @ 130°C		
100°C, Tensile Strength, MPa(psi)	1.7(247)	1.2(175) min.

MEDIUM VOLTAGE (15 KV) INSULATION Continued

Jacket Original Properties		
Tensile Strength, MPa(psi)	17.5(2530)	16.3(1500) min.
Elongation, %	322	100 min.
Air Oven Aged, 120 hrs. @ 100°C		
Tensile Retention, %	102	60 min.
Elongation Retention, %	92	85 min.
	Completed Cable	**Required AE1C #6**
Oil Immersion, 4 hrs. @ 70°C		
Tensile Retention, %	95	60 min.
Elongation Retention, %	88	80 min.
Heat Distortion, 1 hr. @ 121°C	8	50 min.
Heat Shock, 1 hr. @ 121°C	No cracks	No cracks
Cold Bend, 2 hr. @ -35°C	No cracks	No cracks
Electrical U Bend Discharge Tests		
Discontinued after 150 hours at 250 V/mil of insulation thickness. Required > 100 hrs.		
High Voltage Time Test		
Sample passed required 200 V/mil of 4 hrs. Final step 146 KV/680 V/mil.		
Structural Stability Test		
Sample heated by circulating current to 90°C and 130°C.		
Power factor, %	1st step	0.375
	4th step	0.316
	Required	1.5
Corona level	1st step	300% voltage rating to ground at 5pC (apparent discharge magnitude)
	4th step	300% voltage rating to ground at 5pC
	Required	150% rated voltage to ground at 5pC

MEDIUM VOLTAGE (15 KV) INSULATION Continued

DIELECTRIC CONSTANT	
14 days @ 75°C, %	3.6
Required, %	4.0 max.
Power Factor	
14 days @ 75°C, %	1.1
Required, %	1.5 max.
Electrical Stability in Water @ 75°C	
Increase SIC, 1-14 days, %	1.4
Required, %	3.0 max.
Increase SIC, 7-14 days, %	0.41
Required, %	1.5 max.
Stability factor after 14 days, %	0.34
Required, %	1.0 max.

NON-BLACK AUTOMOTIVE BUMPER STRIP

DSM

Keltan 7506	100.0
Hard Clay	100.0
Zeolex 23	25.0
Titanox	30.0
Sunpar 150	35.0
A-C Polyethylene 617	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
Diethylene Glycol	1.5
MOTS #1	3.0
ZBDC	3.0
DTDM	1.0
TEDC	0.5
Sulfur	0.8
Total	310.8
Physical Properties	
Specific Gravity	1.37
Compound Viscosity, ML (1+4) 100°C	73
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	12.6
Press Cure @ 168°C, 10 min. cure	
Tensile, MPa	11.2
Elongation, %	630
300% Modulus, MPa	4.0
Hardness, Shore A	68
Plied Compression Set, %	
22 Hrs. @ 70°C, 15 min. cure	37.8
Ozone Resistance, 100 pphm, 70 Hrs. @ 40°C	NC
Staining Resistance, ASTM D925, Method B	Passed
Weatherometer Exposure	
Discoloration after 200 Hrs.	nil
After Air Oven Aging, 10 min. cure, 70 Hrs. @ 70°C	
Tensile, % Change	-3.1
Elongation, % Change	-28.5
Hardness, Pts. Change	+5

BRAKE CUP
DSM

Keltan 4506	100.0
N-774 Black	55.0
Agerite Resin D	2.0
Zinc Oxide	5.0
DiCup 40C	8.0
Total	170.0
Physical Properties	
Specific Gravity	1.10
Compound Viscosity, ML (1+4) 100°C	82
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	26.5
Press Cure @ 160°C, 10 min. cure	
Tensile, MPa	17.2
Elongation, %	310
100% Modulus, MPa	2.1
Hardness, Shore A	67
Compression Set, %	
22 Hrs.@ 121°C, 30 min. cure	29.3
Low Temperature Brittleness	
3 Min. @ -40°C, 20 min. cure	Passed
After Air Oven Aging, 70 Hrs. @ 125°C, 10 min. cure	
Tensile, % Change	+3.0
Elongation, % Change	-6.0
Hardness, Pts. Change	+1
After Aging in Wagner 21-B Brake Fluid	
70 Hrs. @ 121°C, 10 min. cure	
Tensile, % Change	+9.0
Elongation, % Change	nil
Hardness, Pts. Change	-2
Volume, % Change	+1.9

MASTER CYLINDER RESERVOIR DIAPHRAGM

DSM

Keltan 40A	100.0
N-774 Black	50.0
Naphthenic Oil	10.0
Ricon 154	10.0
Zinc Oxide	5.0
Agerite Resin D	0.5
DiCup 40C	8.5
Total	184.0
Physical Properties	
Specific Gravity	1.06
Compound Viscosity, ML (1+4) 100°C	59
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	30+
Press Cure @ 166°C, 15 min. cure	
Tensile, MPa	16.0
Elongation, %	620
300% Modulus, MPa	5.5
Hardness, Shore A	57
Compression Set, %	
70 Hrs. @ 100°C, 30 min. cure	22.1
Ozone Resistance, 7 Days @ 38°C, 200% Elongation	
50 pphm, 15 min. cure	NC
Low Temperature Flexibility	
After 70 Hrs. @ -40°C, 15 min. cure	NC
Tear Die “C”, kN/m, 20 min. cure	33.3
After Air Oven Aging, 70 Hrs. @ 121°C, 15 min. cure	
Tensile, % Change	-6.5
Elongation, % Change	-1.7
Hardness, Pts. Change	+1
After Aging in Brake Fluid, 120 Hrs. @ 70°C, 15 min. cure	
Tensile, % Change	-4.4
Elongation, % Change	-4.8
Hardness, Pts. Change	+5
Volume, % Change	-4.3

SOLID TIRE
DSM

Keltan 5508	100.0
N-550 Black	150.0
Mineral Black 126	300.0
Sunpar 2280	150.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	1.0
TMTD	0.7
DPTH	0.7
TEDC	0.7
Sulfur	2.0
Total	711.1
Physical Properties	
Specific Gravity	1.25
Mooney Scorch @ 121°C	
Min. to 5 Pt. rise	15.9
Minimum Reading	19
Press Cure @ 171°C, 15 min. cure	
Tensile, MPa	3.6
Elongation, %	210
200% Modulus, MPa	3.6
Hardness, Shore A	78

BRAKE CUP
R.T. Vanderbilt

Nordel 1320	100.0
Zinc Oxide	5.0
AGERITE RESIN D	1.5
FEF (N-550) Black	45.0
VAROX DCP-40C	10.0
Total	161.5
Press Cured 6’ 188°C(370°F)	
Tensile Strength Mpa (psi)	15.2(2200)
Elongation, %	260
Hardness, Shore A	67
Oven Aged 177°C(350°F) 22 Hrs.	
Tensile % Change	-8
Elongation % Change %	0
Hardness, Pts. Change	+4
Compression Set B, % Set	14
Immersed 22 Hrs. 177°C(350°F) - Wagner 21B Brake Fluid (Change)	
Tensile, % Retained	-6
Elongation, % Retained	-1
Hardness, Pts. Change	-4
Volume, % Change	+6

AUTOMOTIVE CLOSED CELL EXTRUDED SPONGE

MICROWAVE CURING

Uniroyal

Masterbatch	
Royalene 645	175.0
GPF N-660	110.0
FEF N-550	20.0
Whiting	30.0
Zinc Oxide	4.0
Stearic Acid	1.0
Brown Factice	15.0
Sunpar 2280	70.0
Total	**425.0**

Mixing Instructions

Banbury, High speed. 0’ add all ingredients and then the Royalene.
1’ Raise and scrape ram at 125°C(257°F) drop batch

Acceleration Addition	
Masterbatch	425.0
Naugex® MBT	1.7
Tellurac	1.0
Butazate® Powder	1.7
Sulfads	1.7
Sulfur	2.0
Celogen® AZ-199	7.5
Total	**440.6**

Mixing Instructions

Banbury, Low speed
0’ Load ½ MB, all ingredients, remaining ½ MB
1’ Raise and scrape ram at 75°C(167°F) drop batch

Test Results	
ML-4 @ 100°C(212°F)	32
Density, lbs./ft^3	34
Density, kg/m^3	544
Elongation, %	350
Tear, Die C, lbs./in.	54
Tear, Die C, N/m	6.1
Durometer Shore A	65
Ozone, 50 pphm @ 48°Cfor 70 hr., 40% Elongation	No cracking

In this process, the soft bulb is either co-vulcanized to a mechanical rubber base or adhered to a vinyl cover strip.

DENSE AUTOMOTIVE EXTRUSION COMPOUND

Uniroyal

Masterbatch	
Ingredients	
Royalene 563	100.0
N-660 GPF Black	100.0
N-550 FEF Black	50.0
Whiting	45.0
Zinc Oxide	10.0
Zinc Stearate	1.5
Calcium Oxide 80%	10.0
Sunpar 2280	110.0
Resin SP-1068	2.0
Naugawhite® Powder	1.5
Carbowax 3350	2.0
Total	**432.0**

Mixing Procedure

Banbury upside down procedure

Drop @ 135°C

Acceleration

Ingredients	**PHR**
Masterbatch	432.0
MBT	1.5
Butazate®	1.5
Sulfads	1.2
Tuex®	1.0
Sulfur	1.5
Total	**438.7**

Mixing Procedure

Banbury, Low Speed

0 min. Load ½ masterbatch, all ingredients, then second half of masterbatch.

At 70°C raise and scrape ram

At 90°C drop batch

Curing Conditions:

Microwave Hot Air – 3 minutes @ 215°C

DENSE AUTOMOTIVE EXTRUSION COMPOUND
Continued

Physical Properties	
Tensile MPa (psi)	8.7(1260)
% Elongation	400
Hardness, Shore A	60
Mooney Viscosity, ML (1+4) @ 100°C	45
Mooney Scorch, MS @ 120°C, t3	10 minutes

70 SHORE A DENSE AUTOMOTIVE EXTRUSION COMPOUND

Uniroyal

Masterbatch	
Ingredients	
Royalene 509	100.0
N-550 FEF Black	75.0
N-774 SRF Black	120.0
Zinc Oxide	10.0
Zinc Stearate	1.5
Calcium Oxide 80%	10.0
Sunpar 2280	100.0
Resin SP-1068	2.0
Naugawhite® Powder	1.5
Carbowax 3350	2.0
AC-617 Polyethylene	10.0
Total	**432.0**

Mixing Procedure

Banbury upside down procedure. Drop at 135°C.

Acceleration

Ingredients	**PHR**
Masterbatch	432.0
MBT	1.5
Butazate®	1.5
Sulfads	1.2
Tuex®	1.0
Sulfur	1.5
Total	**438.7**

Mixing Procedure

Banbury, Low Speed. 0 min. Load ½ masterbatch, all ingredients, then second half of masterbatch. At 60°C raise and scrape ram At 75°C drop batch

Curing Conditions: Microwave Hot Air – 3 minutes @ 215°C

Physical Properties	
Tensile MPa (psi)	9.0(1305)
% Elongation	350
Hardness, Shore A	70
Mooney Viscosity, ML (1+4) @ 100°C	50
Mooney Scorch, MS @ 120°C, t3	6 minutes

80 SHORE A DENSE AUTOMOTIVE EXTRUSION COMPOUND

Uniroyal

Masterbatch

Ingredients	**Phr**
Royalene 535	75.0
Royalene 552	25.0
Ricon 153(Polybutadiene)	15.0
N-762 SRF Black	160.0
Zinc Oxide	10.0
Zinc Stearate	1.5
Calcium Oxide (80% Disp.)	5.0
Sunpar 150	50.0
AC-617 Polyethylene	10.0
Okerin Wax	5.0
Carbowax 3350	2.0
Total	**358.5**

Mixing Procedure

Banbury, Upside down mix procedure, Drop at 160°C

Acceleration

Ingredients	**Phr**
Masterbatch	358.5
MBT	1.5
Butazate®	1.5
Sulfads	1.2
Tuex®	1.0
Sulfur	6.0
Total	**369.7**

Mixing Procedure

Banbury, Low Speed, 0 min. Load ½ masterbatch, all ingredients, then second half of masterbatch. At 60°C raise and scrape ram. At 75°C drop batch.

Curing Conditions: Microwave Hot Air – 3 minutes @ 215°C

Physical Properties

Tensile, MPa (psi)	11.2(1625)
% Elongation	160
Tear Strength, N/mm (lb/in)	5.7(33)
Hardness Shore A	82

80 SHORE A DENSE AUTOMOTIVE EXTRUSION COMPOUND Continued

Aged 7 Days @ 70°C	
Hardness Change	+1
Tensile Change, MPa	+0.2
Elongation Change, %	0
Compression Set, 22 hours @ 70°C, %	30.0
Mooney Viscosity, ML 1+4 @ 100°C	47
Mooney Scorch, MS @ 120°C, t3	5 minutes

EXTRUSION COMPOUNDS
R.T. Vanderbilt

ASTM D 2000	**BA 615****	**BA 815****
Nordel 2760	100.0	100.0
Stearic Acid	1.0	1.0
Zinc Oxide	3.0	3.0
A-C 617 Polyethylene	----	15.0
Naphthenic Oil	140.0	65.0
GPF Black (N-650)	120.0	50.0
SRF Black (N-774)	40.0	140.0
Sulfur	1.5	1.5
ALTAX	1.0	1.0
METHYL TUADS	1.5	1.5
METHYL ZIMATE	1.0	1.0
Total	409.0	378.5
Cured 30 Minutes at 160°C(320°F)		
Tensile Strength, MPa (psi)	12.3(1790)	12.4(1810)
Elongation, %	400	210
Hardness, Shore A	64	81
Heat Aged 70 Hours at 100°C(212°F)		
Tensile, % Change	+8	+7
Elongation, % Change	-15	-16
Hardness, Points Change	+4	+3
Mooney Scorch and Plasticity		
Scorch, t5 at 125°C(257°F)	20	17
Plasticity, ML at 100°C(212°F)	26	63
Compression Set, After 22 Hours at 100°C(212°F)		
% Set	20	24

**Data from Pawling Corporation

EXTRUSION COMPOUNDS, MICROWAVE CURE

R.T. Vanderbilt

ASTM D 2000	BA 615**	BA 715**
Nordel 2760	100.0	100.0
Stearic Acid	1.0	1.0
Zinc Oxide	5.0	5.0
VANWAX H SPECIAL	3.0	4.0
GPF Black (N-650)	105.0	180.0
Desical P	8.0	8.0
Sunpar 2280	75.0	95.0
VANFRE M	5.0	5.0
VANAX NS	1.0	1.0
METHYL TUADS	1.0	1.0
ETHYL TELLURAC	1.0	1.0
Sulfur	2.0	1.0
BUTYL ZIMATE	3.0	3.0
Total	310.0	405.0
Cured 20 Minutes at 160°C(320°F)		
Tensile Strength, MPa (psi)	12.5(1810)	11.2(1620)
Elongation, %	410	320
Hardness, Durometer A	65	73
Heat Aged 70 Hours at 70°C(158°F)		
Tensile, % Change	+5	+6
Elongation, % Change	-4	-8
Hardness, Points Change	+3	+2
Compression Set, After 22 Hours at 70°C(158°F)		
% Set	40	18
Ozone Resistance D 1171 100 Hrs. at 50 ppm, 40°C (104°F), 20% Strain	Pass	Pass
Low Temperature D 2137 at -40°C	Pass	Pass

**Data from Pawling Corporation

DENSE EXTRUSION COMPOUND FOR LCM CURE
R.T. Vanderbilt

Nordel 2744P	100.0
Zinc Oxide	5.0
Stearic Acid	1.0
GPF Black (N-650)	110.0
SRF Black (N-774)	70.0
Circosol 4240	110.0
CAPTAX	1.0
BUTYL ZIMATE	2.0
Sulfur	1.5
UNADS	0.8
ETHYL TELLURAC	0.7
Desical P	8.0
Total	410.0
Mooney Scorch, MS 121°C (250°F)	
Minimum Viscosity	29.0
Time to 10 Pt. Rise, Minutes	7.3
ODR 177°C(350°F) 6 Min. (Microdie, 3 Arc, 100 cpm)	
ML, dN”m(in-lb)	0.9(8.0)
MH, dN”m(in-lb)	7.2(64.0)
ts2, Minutes	0.8
t90, Minutes	4.0
Stress/Strain Hardness, Press Cure - 200°C(392°F) 10 Min.	
100% Modulus, MPa (psi)	5.1(740)
Tensile Strength, MPa (psi)	12.0(1750)
Elongation, %	260
Hardness, Shore A	78
LCM Cure 200°C(392°F) 60 Sec.	
100% Modulus, MPa (psi)	3.3(480)
Tensile Strength, MPa (psi)	9.9(1440)
Elongation, %	355
Hardness, Shore A	72
Compression Set - Method B % (Pellets)	
Cured 15 Min. 200°C(392°F)	
70°C(158°F)	16
100°C(212°F) 22 Hrs.	22

GENERAL PURPOSE MOLDING COMPOUND

Union Carbide

ElastoFlo™ MEGA-6322	Value	Typical Value	Test Method
Polymer Composition			**ASTM**
Ethylene	Medium		D 3900*
ENB	Low		Internal
Physical Form			
Granular, Average Particle Size,mm	0.8		D 1511*
PRODUCT CARBON BLACK CONTENT			
N-650, phr.	22		Internal
Polymer Mooney Viscosity			
ML 1 + 4 @ 125°C, MU	65		D 1646*
Test Formula			
EPDM Polymer, phr	100.0 + X		
Sunpar 2280, phr	100.0		
N-762 Black, phr	160 – X		
Zinc Oxide, phr	5.0		
Stearic Acid, phr	1.0		
TMTD, phr	0.8		
MBT, phr	0.6		
MBTS, phr	1.5		
Butyl Zimate, ZDBC, phr	0.6		
Sulfads, DPTT, phr	0.8		
Sulfur, phr	1.0		
Total	**371.3**		
X = carbon black content of granular form			
Mooney Scorch, 121°C			
ML 1+4 @ 121°C, MU	30		
t(5), min.	12.0		D 1646
MDR Curemeter, 0.5° arc, 175°C			
S'(H), dNm	8.5		D 5289
S'(H)-S'(L), dNm	7.2		D 5289
t(90), min.	6.1		D 5289

*UCC modified

GENERAL PURPOSE MOLDING COMPOUND
Continued

Vulcanizate Physicals			
Tensile Strength, MPa	9.0	>8.0	D 412
100% Modulus, MPa	1.8		D 412
200% Modulus, MPa	3.6		
300% Modulus, MPa	5.1		
Elongation, %	560	>400	D 412
Hardness, Shore A	52	50-60	D 2240
Tension Set			
Recovery after 350% Elongation, %	86	>80	
Tear Resistance, Die 'C', kN/m	34	>25	D 624

TRANSFER MOLDING COMPOUND
DSM

Keltan 4506	100.0
N-550 Black	80.0
N-774 Black	20.0
Sunpar 2280	65.0
Paraffin Wax	3.0
Cumar R-16	15.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	1.2
DPTH	0.6
TMTD	0.6
TEDC	0.6
Sulfur	1.0
Total	293.0
Physical Properties	
Specific Gravity	1.11
Compound Viscosity, ML (1+4) 100°C	38
Mooney Scorch @ 132°C	
Min. to 3 Pt. Rise	7.0
Minimum Reading	14
Press Cure @ 160°C, 6 min. cure	
Tensile, MPa	10.3
Elongation, %	610
300% Modulus, MPa	5.2
Hardness, Shore A	59
Compression Set, %, 20 min. cure, 22 Hrs. @ 70°C	22.8
Ozone Resistance, 20 min. cure, 100 pphm, 70 Hrs. @ 40°C	NC
Low Temprature Brittle Point, °C, 20 min. cure	-54
After Air Oven Aging, 6 min. cure, 70 Hrs. @ 100°C	
Tensile, % Change	-16.6
Elongation, % Change	-33.2
Hardness, Pts. Change	+4

HIGH SPEED EXPANDER ROLL
DSM

Keltan 7506	100.0
Hard Clay	40.0
Hi-Sil 233	30.0
Titanium Dioxide	5.0
Sunpar 2280	30.0
Agerite Resin D	2.0
Zinc Oxide	5.0
Diethylene Glycol	2.0
DiCup 40C	10.0
Total	224.0
Physical Properties	
Specific Gravity	1.17
Compound Viscosity, ML (1+4) 100°C	75
Mooney Scorch @ 132°C	
Min. to 3 Pt. Rise	30
Press Cure @ 160°C, 15 min. cure	
Tensile, MPa	13.8
Elongation, %	770
300% Modulus, MPa	2.9
Hardness, Shore A	60
Compression Set, %	
22 Hrs. @ 70°C, 40 min. cure	16.8
After Air Oven Aging, 70 Hrs. @ 149°C, 15 min. cure	
Tensile, % Change	+1.25
Elongation, % Change	-24.7

90 DUROMETER NON-BLACK ROLL COMPOUND

Uniroyal

Royalene® 501	90.0
Trilene® 65	10.0
Hi-Sil 532EP	60.0
Hard Clay	50.0
Titanium Dioxide	5.0
Sunpar 2280 Oil	15.0
Zinc Oxide	5.0
Saret 518	20.0
Dicumyl Peroxide, 60%	4.5
Total	**259.5**
Mooney Viscosity	
ML (1+4) @ 100°C	75
Press Cure 30 minutes @ 160°C(320°F)	
Hardness, Shore A	91
100% Modulus, MPa (psi)	7.1(1025)
Tensile Strength, MPa (psi)	9.1(1320)
Elongation, %	160
Tear, Die C, kN/m(lb/in)	29.0(168)

BOAT DOCK BUMPER
DSM

Keltan 7506	100.0
N-550 Black	90.0
Sunpar 2280	60.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	0.6
TMTM	1.2
Sulfur	1.0
Total	258.8
Physical Properties	
Specific Gravity	1.10
Compound Viscosity, ML (1+4) 100°C	65
Mooney Scorch @ 132°C, Min. to 3 Pt. Rise	21.5
Minimum Reading	26
Press Cure @ 160°C, 20 min. cure	
Tensile, MPa	13.5
Elongation, %	450
300% Modulus, MPa	8.6
Hardness, Shore A	64
Compression Set, %	
22 Hrs. @ 100°C, 30 min. cure	31.2
Low Temperatue	
Brittle Point, °C, 20 min. cure	-57
Ozone Resistance, 70 Hrs. @ 40°C	
1000 pphm	NC
After Air Oven Aging, 70 Hrs. @ 100°C, 20 min. cure	
Tensile, % Change	-10.1
Elongation, % Change	-26.6
Hardness, Pts. Change	+1

40 DUROMETER NON-BLACK ROLL COMPOUND

Uniroyal

Royalene® 501	50.0
Royalene® 400	100.0
Silene 732D	30.0
Mistron Vapor Talc	40.0
Carbowax 3350	1.0
Factice	25.0
Sunpar 2280 Oil	30.0
Zinc Oxide	5.0
Stearic Acid	1.0
Monex®	1.5
MBT	1.5
Naugex® SD-1	1.0
Sulfur	1.5
Total	**287.5**
Mooney Viscosity	
ML (1+4) @ 100°C	32
Press Cure 30 Minutes @ 160°C	
Hardness, Shore A	38
300% Modulus, MPa (psi)	1.5(220)
Tensile Strength, MPa (psi)	7.0(1020)
Elongaiton, %	790
Tear Strength Die C, kN/m(lb/in)	21(120)
Compression Set	
22 hours @ 70°C	40%

50 SHORE A DENSE EXTRUSION COMPOUND

Uniroyal

Masterbatch	
Royalene 552	100.0
N-660 GPF Black	150.0
N-774 SRF Black	50.0
Whiting	75.0
Zinc Oxide	10.0
Zinc Stearate	1.5
Calcium Oxide (80% Disp.)	12.0
Sunpar 2280	110.0
Resin SP-1068	2.0
Naugawhite® Powder	1.5
Carbowax 3350	2.0
Total	**514.0**

Mixing Procedure

Banbury upside down procedure. Drop at 135°C

Acceleration

Ingredients	**PHR**
Masterbatch	514.0
MBT	1.5
Butazate®	1.5
Sulfads	1.2
Tuex®	1.0
Sulfur	1.5
Total	**520.7**

Mixing Procedure

Banbury, Low Speed, 0 min. Load ½ masterbatch, all ingredients, then second half of masterbatch.

At 70°C raise and scrape ram. At 90°C drop batch

Curing Conditons: Microwave Hot Air – 3 minutes @ 215°C

Physical Properties	
Tensile MPa (psi)	8.0(1160)
% Elongation	350
Hardness, Shore A	51
Mooney Viscosity, ML (1+4) @ 100°C	40
Mooney Scorch, MS @ 120°C, t3	12 minutes

PRESS MOLDED CLOSED CELL SHEET SPONGE
NON-OIL RESISTANT
Uniroyal

	1	2	3
Royalene® 521	80.0	----	----
Royalene® 512	20.0	----	----
Royalene® 525	----	----	35.0
SBR 1506	----	40.0	----
SBR 8140	----	----	81.25
SBR 4906	----	100.0	----
Stearic Acid	1.0	4.0	3.0
Zinc Oxide	4.0	5.0	5.0
Suprex Clay	115.0	100.0	100.0
Mistron Vapor	45.0	45.0	45.0
N550 FEF Black	10.0	10.0	10.0
Petrolatum	8.0	8.0	8.0
Circosol 4240	50.0	45.0	45.0
Sunproof® Improved Wax	----	5.0	5.0
Naugawhite® Powder	----	2.0	----
Sulfur	2.0	2.0	4.0
Naugex® MBTS	1.0	1.0	----
Delac® S	----	----	0.7
ZMBT	----	----	0.7
Celogen® AZ-130	12.0	12.0	12.0
BIK®-OT	2.0	2.0	----
Total	**350.0**	**381.0**	**354.65**
Press Precure - 28 minutes @ 143°C(290°F)			
Oven Expand and Normalize - 1.5 hours @ 160°C(320°F)			
Density, lb/ft3(kg/m^3)	9(144)	9(144)	9(144)

The above compounds are typical 2A1 (RE-41) types.
Adjust the cure and blow systems for 2A2 (RE-42) and 2A3 (RE-43).

EXTRUDED SPONGE COMPOUND FOR LCM CURING

Uniroyal

Masterbatch

Ingredients	
Royalene® 645	175.0
N-660 Black	65.0
N-550 Black	25.0
Whiting	40.0
Mistron Vapor	30.0
Zinc Oxide	5.0
Stearic Acid	1.0
TE-28 G-9	2.0
Sunpar 2280	85.0
Total	**428.0**

Mixing Instructions

Banbury, High Speed. 0 min. Load all ingredients, then the Royalene EPDM. At 110°C raise and scrape ram. At 130°C drop batch.

Acceleration

Ingredients	**phr**
Masterbatch	428.0
MBT	1.5
Arazate®	1.5
GeniPlex A-75	1.0
Royalac® 136A	1.0
Accelerator A-1	1.5
Sulfur	2.0
Celogen® AZ 199	4.0
Celogen® AZ 130	2.0
Total	**442.5**

Mixing Instructions

Banbury, Low Speed. 0 Min. Load ½ of the Masterbatch, all ingredients, then the second ½ of the Masterbatch. At 60°C Raise and scrape ram. At 75°C drop batch.

Curing Conditions – LCM

2 ½ minutes @ 215°C (Using a Cascade System)

EXTRUDED SPONGE COMPOUND FOR LCM CURING Continued

Physical Properties	
Density g/ml	0.48
Tensile, MPa	2.80
Tear, Die C, N/mm	2.50
% Water Abs. (Vac.)	0.30
% Compression Set,	26.20
(50% Deflection, for 22 hours @ 70°C, ½ hour recovery)	
Mooney Viscosity, ML 1+4 @ 100°C	42
Mooney Scorch @ 120°C	4.75’
Skin Surface	Smooth
Cell Size	Medium

SPONGE COMPOUND FOR INJECTION MOLDING

Uniroyal

Masterbatch	
Royalene 535	70.0
Royalene 645	52.5
N-550 Black	40.0
Whiting	40.0
Catalpo Clay	75.0
Zinc Oxide	5.0
Stearic Acid	1.0
TE-28 G-9	4.0
Sunpar 2280	100.0
Total	**387.5**

Mixing Instructions

Banbury, High Speed. 0 Min. Load all the ingredients, then the Royalene. At 100°C raise and scrape ram. At 115°C, drop batch.

Acceleration

Ingredients	**phr**
Masterbatch	387.5
BIK-OT	3.0
Celogen® OT	6.5
MBTS	1.0
MBT	0.5
Arazate®	1.8
Accelerator A-1	1.0
Sulfur	1.8
Total	**403.3**

Mixing Instructions

Banbury, Low Speed. 0 Min. Load ½ of the Masterbatch, all ingredients, then the second ½ of the Masterbatch. At 60°C raise and scrape ram. At 75°C, drop batch.

Curing Conditions

175°C Mold Temperature for 3 to 5 minutes depending on the size of the corner being produced

SPONGE COMPOUND FOR INJECTION MOLDING Continued

Physical Properties	
Density g/mL	0.52
Tensile, MPa	2.3
Tear, Die C, N/mm	2.1
% Water Abs. (Vac.)	0.8
% Compression Set,	43
(50% Deflection, for 22 hours @ 70°C, ½ hour recovery)	
Mooney Viscosity, ML 1+4 @ 100°C	14
Mooney Scorch @ 120°C	21.3’
Skin Surface	Smooth
Cell Size	Fine

FLAME RESISTANT COMPOUND
DSM

Keltan 7506	100.0
N-550 Black	100.0
Antimony Trioxide	20.0
Sunpar 150	10.0
Unichlor 70AX	20.0
Zinc Oxide	5.0
Stearic Acid	1.0
TMTD	0.5
MBT	1.5
Sulfur	1.5
Total	259.5
Physical Properties	
Specific Gravity	1.28
Compound Viscosity, ML (1+4) 100°C	41
Steam Cure @ 154°C, 20 Min. Cure, 0.54 MPa	
Tensile, MPa	17.2
Elongation, %	330
300% Modulus, MPa	16.2
Hardness, Shore A	78
Low Temperature Brittle Point, °C	
3 Min. Cure, 40°C	Passed
Ozone Resistance	
100 pphm, 70 Hrs. @ 40°C	NC

MICROWAVE CURE FORMULA
DSM

Keltan 5251A	115.0
N-550 FEF Black	70.0
N-77 SRF HM Black	75.0
Sunpar 2280	60.0
Petrolatum	5.0
TE-80	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
ZMDC	1.5
ZBDC	1.5
TMTD	1.0
DTDM	1.5
Sulfur	0.5
Desical P	10.0
Total	352.0
Physical Properties	
Compound Viscosity, ML (1+4) 100°C	70
Mooney Scorch @ 132°C	
Min. to 5 Pt. Rise	7
Minimum Reading	42
Press Cure @ 165°C, 20 min. cure	
Tensile, MPa	10.3
Elongation, %	220
100% Modulus, MPa	6.6
200% Modulus, MPa	9.8
Hardness, Shore A	70
Compression Set, %	
22 Hrs. @ 70°C, 40 min. cure	25

WATER SPORTS EQUIPMENT
DSM

Keltan P557	150.0
N-550 Black	75.0
Sunpar 2280	90.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	1.0
TMTD	0.5
CDEDC	0.5
ZMDC	0.5
Sulfur	1.0
Total	324.5
Physical Properties	
Specific Gravity	1.03
Compound Viscosity, ML (1+4) 100°C	30
Mooney Scorch @ 121°C	
Min. to 3 Pt. rise	30+
Press Cure @ 160°C, 10 min. cure	
Tensile, MPa	16.0
Elongation, %	900
300% Modulus, MPa	2.2
Hardness, Shore A	42
Tear Die “C”, kN/m, 10 min. cure	33.3
After Air Oven Aging	
70 Hrs. @ 100°C, 10 min. cure	
Tensile, % Change	-14.0
Elongation, % Change	-28.9
Hardness, Pts. Change	+5
After Aging in Water	
70 Hrs. @ 100°C, 10 min. cure	
Tensile, % Change	+1.0
Elongation, % Change	-23.7
Hardness, Pts. Change	-5
Volume, % Change	+0.5

NON BLACK SPORTS EQUIPMENT

DSM

Keltan P557	150.0
Silene 732D	70.0
Sunpar 150	40.0
A-C Polyethylene 617A	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
Silane A-189	1.0
Carbowax 3350	2.0
TMTM	1.0
MBTS	0.60
ZBDC	2.0
Sulfur	1.0
Total	278.60
Physical Properties	
Specific Gravity	1.05
Compound Viscosity, ML (1+4) 100°C	43
Mooney Scorch @ 121°C	
Min. to 3 Pt. rise	13
Press Cure @ 163°C, 10 min. cure	
Tensile, MPa	17.1
Elongation, %	870
300% Modulus, MPa	2.1
Hardness, Shore A	45
Tension Set, %, 15 min. cure	3.2
Ozone Resistance, 70 Hrs. @ 38°C, 15 min. cure	
100 pphm	NC
Tear Die “C”, kN/m, 10 min. cure	27.1
After Air Oven Aging, 70 Hrs. @ 100°C, 10 min. cure	
Tensile, % Change	-29.3
Elongation, % Change	-27.6
Hardness, Pts. Change	+2

OUTDOOR MATTING
DSM

Keltan P597	200.0
N-550 Black	100.0
Austin Black	400.0
Sunpar 2280	85.0
Cumar R-16	5.0
A-C Polyethylene 617	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	1.0
DPTH	1.0
TMTD	0.75
TEDC	1.0
Sulfur	2.0
Total	806.75
Physical Properties	
Specific Gravity	1.12
Compound Viscosity, ML (1+4) 100°C	66
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	21.4
Press Cure @ 160°C, 20 min. cure	
Tensile, MPa	3.6
Elongation, %	120
100% Modulus, MPa	3.5
Hardness, Shore A	70
Compression Set, %	
22 Hrs. @ 70°C, 30 min. cure	20.2
22 Hrs. @ 100°C, 30 min. cure	37.5
Ozone Resistance	
70 Hrs. @ 40°C, 20 min. cure, 100 pphm	NC
Low Temperature Brittle Point, °C, 20 min. cure	-51
After Air Oven Aging, 70 Hrs. @ 100°C, 20 min. cure	
Tensile, % Change	+14.2
Elongation, % Change	nil
Hardness, Pts. Change	+4

GUN STOCK PAD
DSM

Keltan 7506	100.0
Hard Clay	100.0
Whitetex	25.0
Titanium Dioxide	30.0
Sunpar 150	90.0
A-C Polyethylene 617A	5.0
Paraffin Wax	5.0
Petrolatum	5.0
Zinc Oxide	5.0
Stearic Acid	1.0
MBT	0.75
TMTD	0.75
ZMDC	0.75
DPTH	0.5
Sulfur	1.5
Total	370.25
Physical Properties	
Specific Gravity	1.29
Compound Viscosity, ML (1+4) 100°C	20
Mooney Scorch @ 121°C	
Min. to 5 Pt. Rise	9
Press Cure @ 160°C, 30 min. cure	
Tensile, MPa	7.4
Elongation, %	760
300% Modulus, MPa	1.9
Hardness, Shore A	49
Compression Set, %, 22 Hrs. @ 70°C, 30 min. cure	28.7
Ozone Resistance, 100 pphm, 70 Hrs. @ 40°C, 30 min. cure	NC
Low Temperature Brittleness, 30 min. cure	Passed @ 55°C
After Air Oven Aging, 70 Hrs. @ 60°C, 30 min. cure	
Tensile, % Change	-2.4
Elongation, % Change	-13.1
Hardness, Pts. Change	+3

BUILDING PROFILES
Enichem

DUTRAL TER 4049	100
Zinc oxide	5
Stearic acid	1
Glicogum 4000	2
Mix CaO 75	5
Whiting	25
FEF N550	110
EIL 570 (paraff. oil)	70
Sulphur	0.5
Peroximon F/40	6
Peroximon 164/40	4
Uncured properties	
ML (1+4) @ 100°C	58
MDR @ 180°C	
t2, min.	0.253
t90, min.	1.750
Cured properties (40’/165°C)	
T.S., MPa	11
E.B., %	430
M100, MPa	2.5
M200, MPa	5.5
Tension set at 200%, %	6
Shore A	54
IRHD	58
C. set 22h/-25°C, %	61
C. set 22h.100°C, %	16
Δ IRHD, istant. (166h/-10°C)	+9
Δ IRHD, after 30” (166h/-10°C)	+4
Aged properties (7d/100°C)	
Δ T.S., %	0
Δ E.B., %	+2
Δ IRHD	0

C.V. CURED COMPACT PROFILES (UHF OR LCM CURING)
Enichem

DUTRAL TER 4038	100	
Zinc oxide	5	
Stearic acid	1	
FEF N550	140	
Whiting	30	
Paraffinic oil	100	
Caloxol W-3	6	
Glicogum 4000	5	
MBT	1.2	
TMTDS	0.8	
DTDM	2	
Sulphur	0.8	
Uncured properties		
ML (1+4) @ 100°C	62	
Monsanto ODR @ 160°C		
t2	2’6”	
t90	9’6”	
Cured properties	**Press cure (20’/160°C)**	**UHF + hot air**
T.S., MPa	11	10
E.B., %	430	460
M300 MPa	8.5	7
Shore A	69	67
C. set 70h/70°C,%	17	-
C. set 70h/125°C,%	55	-
Aged properties (72h/70°C)		
Δ T.S., %	+8	-
Δ E.B., %	-12	-
Δ Shore A, points	+3	-
Aged properties (48h/125°C)		
Δ T.S.,%	+9	-
Δ E.B.,%	-58	-
Δ Shore A, points	+5	-

EXPANDED PROFILES (UHF OR "SHEAR HEAD" CURING)
Enichem

DUTRAL TER 9049	100	
Zinc oxide	10	
Stearic acid	1	
FEF N550	50	
MT N990	40	
Socal U1S1	20	
Armide O	4	
Paraffinic oil	65	
Caloxol W-3	4	
Celogen AZ	3	
Celogen OT	2	
CBS	1.5	
TDEDC	1.5	
ZDBDC	2	
DPTTS	1	
Sulphur	1.3	
Uncured properties		
ML (1+4) @ 100°C	30	
Monsanto ODR @ 180°C		
t2	54"	
t90	4'18"	
Cured properties	**UHF***	**Krupp line****
Density, g/cm^3	0.47	0.5
Water absorption, %	0.6	
Load at 50% of deflection, Kg/5 cm	1	1.1
C. set 70h/70°C (5 min.),%	19	24
C. set 70h/70°C(30 min.),%	16	21

* UHF: 4x2.5 Kw, hot air 250°C(12 mt.), extrus. speed 5 mt./1'
** T1 extr. die: 76°C, T2 head: 120°C, rotating mandrel: 92 rpm,
T air oven: 300°C, extr. speed: 10 mt/min.
Note: also suitable for hot air curing (4 min./240°C).

48 SHORE A COMPOUND

Uniroyal

Royalene 637P	175.0
HiSil 532EP	15.0
N650 Black	50.0
N774 Black	100.0
Sunpar 150	90.0
Zinc Oxide	8.3
Stearic Acid	1.5
Poly AC 617A	5.0
Struktol TR131	3.0
Paraffin Wax	3.0
Cumar P25 DLC	5.0
Sulfads	0.7
Tuex®	0.7
Butazate®	1.5
MBTS	2.0
Sulfur	1.5
Total	**462.2**
Mooney Viscosity	
ML (1+4) @ 100°C	35
Unaged Physical Properties, Cures @ 177°C(350°F)	
Hardness, Shore A ,6’	47
Hardness, Shore A , 12’	48
300% Modulus, MPa (psi), 6’	3.4(490)
300% Modulus, MPa (psi), 12’	3.9(560)
Tensile Strength, MPa (psi),6’	12.0(1740)
Tensile Strength, MPa (psi),12’	12.4(1800)
Elongation, %, 6’	810
Elongation, %, 12’	770

621 MPA (90,000 PSI) FLEXURAL MODULUS TPO
Uniroyal

Royalene® 580HT	32.0	
PROFAX 6301	51.0	
T50-200 HDPE	17.0	
Atomite	17.5	
Naugard®10	0.2	
Calcium Stearate	0.1	
Unaged Physical Properties (From Injection Molded Specimens)		
Tensile Strength, MPa(psi)	13.6	(1970)
Elongation at Break, %	280	
Flexural Modulus, MPa (psi x 1000)	620	(90)
Tear Resistance, Die C, kN/m (lb/in)	88	(500)
Gardner Impact, -29°C(-20°F), J(lb-in.)	35+	(312+)
Durometer, Shore D	57	
MFI. Cond. L, 230°C, 2160g	3	
Specific Gravity	0.99	
Aged 7 Days @ 125°C		
Tensile Strength, MPa (psi)	13.3	(1930)
Elongation at Break, %	250	
Durometer, Shore D	58	

241 MPA (35,000 PSI) FLEXURAL MODULUS TPO
Uniroyal

Royalene® 552	68.0	
PROFAX 6301	32.0	
Atomite	7.7	
Naugard®10	0.2	
Calcium Stearate	0.1	
Unaged Physical Properties (From Injection Molded Specimens)		
Tensile Strength, MPa(psi)	11.1	(1600)
Elongation at Break, %	750	
Flexural Modulus, MPa (psi x 1000)	240	(35)
Tear Resistance, Die C, kN/m (lb/in)	98	(560)
Gardner Impact, -29°C(-20°F), J(lb-in.)	35+	(312+)
Durometer, Shore D	48	
MFI. Cond. L, 230°C, 2160g	0.4	
Specific Gravity	0.94	
Aged 7 Days @ 125°C		
Tensile Strength, MPa (psi)	11.3	(1640)
Elongation at Break, %	500	
Durometer, Shore D	48	

1034 MPa(150,000 psi) FLEXURAL MODULUS TPO
Uniroyal

Royalene® 580HT	30.0
Profax 6301	70.0
Atomite	17.5
Naugard® 10	0.2
Calcium Stearate	0.1
Unaged Physical Properties (From Injection Molded Specimens)	
Tensile Strength, MPa (psi)	17.2(2500)
Elongation, % at Break	250
Flexural Modulus, MPa (psi x 10^3)	1030(150)
Tear Resistance, Die C, kN/m (lb/in)	100(570)
Gardner Impact, -29°C (-10°F), J (in.-lb)	35(312)
Durometer, Shore D	62
MFI, Cond. L, 230°C, 2160 g	3.5
Specific Gravity	0.98
Aged 7 Days @ 125°C(257°F)	
Tensile Strength, MPa (psi)	17.2(2500)
Elongation, % at Break	270
Durometer, Shore D	62

Notes:

VI.

NITRILE

FUEL HOSE
DSM

	1	2
Nysyn 30-5	100.0	100.0
Halco 83-SS	5.0	5.0
Mistron Vapor	50.0	50.0
Ciptane	25.0	25.0
N787 Black	20.0	20.0
Laminar	30.0	30.0
Stearic Acid	0.5	0.5
Zinc Oxide	5.0	5.0
VANOX ZMTI	1.0	1.0
Irganox 565	0	1.0
AGERITE SUPERFLEX	2.0	0
Irganox MD 1024	0.5	0.5
TBBS	1.75	1.75
TMTD	2.0	2.0
MBS	1.5	1.5
Spider Sulfur	0.3	0.3
Sartomer 350	0	5.0
Total	244.55	248.55
Physical Properties		
Compound Viscosity, ML (1+4) 100°C	86	74
Mooney Scorch @ 132°C		
Min. to 5 Pt. Rise	9.1	9.4
Minimum Reading	31	27
Press Cure @ 162°C, 20 min. cure		
Tensile, MPa	11.9	15.03
Elongation, %	370	440
100% Modulus, MPa	3.24	2.98
200% Modulus, MPa	5.79	5.3
300% Modulus, MPa	9.17	8.27
Hardness, Shore A	70	75
Compression Set, %		
70 Hrs. @ 100°C, 30 min. cure	29.5	32.1
70 Hrs. @ 125°C, 30 min. cure	50	63.2
After Air Oven Aging 70 Hrs. @ 125°C, 20 min. cure		
Tensile, % Change	+14	-15
Elongation, % Change	-11	-23
Hardness, Pts. Change	+12	+6

FUEL HOSE
Continued

After Immersion in ASTM Oil #3 70 Hrs. @ 100°C, 20 min. cure		
Tensile, % Change	+7	-28
Elongation, % Change	0	-20
Hardness, Pts. Change	0	-7
Volume Change, %	+12.8	+10.6
After Immersion in ASTM Fuel B 70 Hrs. @ 23°C, 20 min. cure		
Tensile, % Change	-52	-60
Elongation, % Change	-32	-43
Hardness, Pts. Change	-9	-15
Volume Change, %	+32.5	+29.6
After Immersion in ASTM Fuel C 70 Hrs. @ 23°C, 20 min. cure		
Tensile, % Change	-62	-68
Elongation, % Change	-51	-55
Hardness, Pts. Change	-12	-17
Volume Change, %	+51.2	+47.4
Low Temperature		
Brittle Point, °C, 20 min. cure	F@-32	F@-32

FUEL HOSE
Enichem

Recipe		
Europrene N OZO 7039		100
ZnO		3
Stearic acid		0.5
Mistron Vapor		12
Vulkanox MB2		2
Anox HB		1.5
Durosil		12
N 990 MT		70
Socal U		12
DOP		9
Struktol WB 300		9
TMTD		3
MBTS		1
Sulphur		0.5
Mooney Compound (1+4) 100°C		30
Scorch at 121°C		
MV	lb*inch	37
T5	min	6.4
T35	min	9.1
Rheometer 160°C, 24’, arc ± 1°		
TS1	min	2.0
T50	min	2.6
T90	min	6.0
MH	lb*inch	42.0
ML	lb*inch	9.5
Press cure 7 min at 160°C		
M100	MPa	4.7
T.S.	MPa	9.9
E.B.	%	440
Hardness ShA	points	75
Compression set 22h 100°C	%	46
Ageing in Air 100h at 110°C		
Δ T.S.	%	5
Δ E.B.	%	-31
Δ ShA	points	4

FUEL HOSE
Continued

Ageing in ASTM #3 oil 70h at 100°C		
Δ T.S.	%	10
Δ E.B.	%	-31
Δ ShA	points	3
Δ Volume	%	-3
Ageing in Fuel C 70h at 23°C		
Δ T.S.	%	-47
Δ E.B.	%	-19
Δ ShA	points	-2
Δ Volume	%	27
Ageing in Fuel D 70h at 23°C		
Δ T.S.	%	-31
Δ E.B.	%	-9
Δ ShA	points	-12
Δ Volume	%	16
Ageing in M1.5 70h at 23°C		
Δ T.S.	%	-64
Δ E.B.	%	-45
Δ ShA	points	-24
Δ Volume	%	41
Ageing in Unleaded Fuel 48h at 23°C		
Δ T.S.	%	-33
Δ E.B.	%	-2
Δ ShA	points	-15
Δ Volume	%	17
Ageing in Unleaded Fuel 70h at 23°C		
Δ T.S.	%	-31
Δ E.B.	%	-77
Δ ShA	points	-17
Δ Volume	%	18
Ageing in Ozone (40°C, 50 pphm, 200h, 20%)		
Cracks	Y/N	N
Ageing in Ozone (40°C, 50 pphm, 200h, 20%) after ageing in Fuel C (70h, 40°C) + 48h 70°C in air		
Cracks	Y/N	N
Corrosion Copper test		
Surface appearance		Very Good

FUEL HOSES
Inner layer
Enichem

Recipe		**1**	**2**	**3**	**4**
Europrene N 3945		-	-	100	-
Europrene N 3060		50	50	-	100
Europrene N 4560		50	50	-	-
ZnO		5	3	5	3
Stearic acid		1	1	1	1
Mistron Vapor		80	50	80	50
N 550 FEF		60	20	60	20
N 990 MT		50	-	50	-
N 772 SRF		-	80	-	80
Bisoflex 111		15	20	15	20
Struktol KW 400		15	15	15	15
Vulkanox 4010 NA		3	-	3	-
Polyplastol 19		2	2	2	2
Vulkanox MB2		-	2	-	2
Anox HB		-	15	-	15
Irganox 1425		-	2	-	2
Durosil		-	25	-	25
TMTD		3	3	3	3
MBTS		1	1	1	1
Sulphur		0.5	0.5	0.5	0.5
Mooney Compound (1+4) 100°C		60	60	50	60
Scorch at 121°C					
MV	lb*inch	42	42.5	34	44
T5	min	11.3	6.9	11.7	6.6
T35	min	13.4	9.2	13.8	8.9
Rheometer 180°C, 24’, arc ± 1°					
ML	lb*inch	4.3	4.7	3.3	4.7
MH	lb*inch	27.7	29.8	27.2	30.6
TS1	min	1.7	1.4	1.8	1.4
T50	min	2.4	2.8	2.6	2.7
T90	min	4.2	5.1	4.5	4.8
Press cure at 180°C for:		5’	6’	5’	5’
M100	MPa	5.9	6.0	5.6	5.8
T.S.	MPa	10.2	10.0	9.8	10.1
E.B.	%	300	275	320	280
Hardness ShA	points	78	78	78	78
Tear resistance	N/mm	45	44	47	43

FUEL HOSES
Inner layer
Continued

		1	**2**	**3**	**4**
Compression set					
24h at 100°C, 30%	%	37	32	35	30
72h at 23°C, 40%	%	20	15	19	13
72h at -5°C, 25%	%	27	23	23	18
Ageing in Air 24h at 100°C					
Δ T.S.	%	9	9	23	4
Δ E.B.	%	-39	-28	-46	-38
Δ ShA	points	7	6	6	4
Δ Weight	%	-2	-2	-2	-2
Ageing in Air 72h at 100°C					
Δ T.S.	%	-1	-2	-2	-3
Δ E.B.	%	-5	-9	-8	-8
Δ ShA	points	1	-1	0	0
Δ Weight	%	0	0	0	0
Ageing in Water 72h at 23°C					
Δ T.S.	%	-1	0	3	4
Δ E.B.	%	-3	6	-3	3
Δ ShA	points	-2	-3	-2	-2
Δ Weight	%	1	1	1	1
Δ Volume	%	0	2	1	2
Ageing in Water 72h at 23°C + Air 48h at 40°C					
Δ T.S.	%	9	-6	4	-10
Δ E.B.	%	-14	2	-21	0
Δ ShA	points	2	-1	1	2
Δ Weight	%	-1	-1	-1	-1
Δ Volume	%	-1	-1	-1	-1
Ageing in Fuel C 72h at 23°C					
Δ T.S.	%	-25	-18	-20	-23
Δ E.B.	%	-27	-20	-30	-24
Δ ShA	points	-17	-18	-18	-16
Δ Weight	%	7	7	8	8
Δ Volume	%	16	15	18	17

FUEL HOSES
Inner layer
Continued

		1	**2**	**3**	**4**
Ageing in Fuel C 72h at 23°C + Air 48h at 40°C					
Δ T.S.	%	-6	-15	-10	-9
Δ E.B.	%	-15	-19	-11	-17
Δ ShA	points	6	8	6	9
Δ Weight	%	-6	-8	-7	-9
Δ Volume	%	-7	-10	-9	-10
Ageing in Ozone 40°C, 20%, 25 pphm					
Cracks after:		8h	8h	8h	8h

GASOLINE RESISTANT LINING

DSM

Nysyn 406 P	100.0
VANFRE AP-2	1.0
NBC	0.75
Nucap 100	50.0
Cybrubond	50.0
Hi-Sil EP	15.0
Flexrich P-4	10.0
Titanium Dioxide	3.0
KP-140	10.0
MBTS	3.0
TMTD	1.5
Spider Sulfur	0.5
High Melt Temperautre Wax	3.0
Flexzone 6H	3.0
DPG	0.8
Zinc Oxide	5.0
Stearic Acid	1.0
Total	257.55
Physical Properties	
Compound Viscosity, ML (1+4) 100°C	38
Mooney Scorch @ 132°C	
Min. to 5 Pt. Rise	3.7
Minimum Reading	19
Press Cure @ 160°C, 15 min. cure	
Tensile, MPa	12.07
Elongation, %	680
100% Modulus, MPa	1.72
200% Modulus, MPa	2.6
300% Modulus, MPa	3.4
Hardness, Shore A	62
Compression Set, %	
70 Hrs. @ 100°C, 25 min. cure	22.6
70 Hrs. @ 125°C, 25 min. cure	38.5

GASOLINE RESISTANT LINING
Continued

After Air Oven Aging 70 Hrs. @ 125°C, 15 min. cure	
Tensile, % Change	-11
Elongation, % Change	-7
Hardness, Pts. Change	+8
After Immersion in ASTM Oil #1 70 Hrs. @ 100°C, 15 min. cure	
Tensile, % Change	+7
Elongation, % Change	-12
Hardness, Pts. Change	+13
Volume Change, %	-11
After Immersion in ASTM Oil #3 70 Hrs. @ 100°C, 15 min. cure	
Tensile, % Change	-16
Elongation, % Change	-7
Hardness, Pts. Change	+3
Volume Change, %	-3
After Immersion in ASTM Fuel B 70 Hrs. @ 23°C, 15 min. cure	
Tensile, % Change	-49
Elongation, % Change	-6
Hardness, Pts. Change	-14
Volume Change, %	+22
After Immersion in ASTM Fuel C 70 Hrs. @ 23°C, 15 min. cure	
Tensile, % Change	-51
Elongation, % Change	-15
Hardness, Pts. Change	-16
Volume Change, %	+27
Low Temperature Brittle Point, °C, 15 min. cure	F@-30

TRUCK FUELING HOSE TUBE
Goodyear

	1	2	3	4
Chemigum N206	100.00	100.00	100.00	100.00
N347 Carbon Black	40.00	40.00	40.00	40.00
Mistron Vapor	40.00	40.00	30.00	30.00
Hard Clay	20.00	0.00	0.00	0.00
Hercoflex 900	15.00	15.00	0.00	15.00
Santicizer 261	20.00	20.00	20.00	20.00
Turpol NC1200	0.00	0.00	15.00	0.00
TP-90B	15.00	15.00	15.00	15.00
Carbowax 3350	2.00	2.00	2.00	2.00
Stearic Acid	0.50	0.50	0.50	0.50
NBC	1.00	1.00	1.00	1.00
Wingstay L	2.00	2.00	2.00	2.00
Sulfur, Spider Brand	0.65	0.65	0.65	0.65
Unads	1.40	1.40	1.40	1.40
Zinc Oxide	5.00	5.00	5.00	5.00
Total	**262.55**	**242.55**	**232.55**	**232.55**
Rheometer, 163°C, 3° Arc, 100 CPM, 60 Min. Motor				
Torque, Min.	2.5	1.7	1.7	2.0
Torque, Max.	16.8	12.9	9.5	15.3
TS 2, minutes	5.5	5.7	6.8	5.5
T'C90, minutes	8.7	10.0	10.0	8.5
T'C95, minutes	13.0	14.0	13.5	10.8
Scorch, MS/121°C				
Minimum	7.0	6.0	7.0	6.0
T5, minutes	55.6	59.2	----	----
60 min. Reading	----	----	7.1	6.1
Specific Gravity	1.324	1.277	1.242	1.243
Original Physical Properties, Cured 15' @ 163°C				
Tensile, psi	2025	2120	2060	2100
Elongation, %	725	750	800	800
200% Modulus, psi	300	220	200	150
300% Modulus, psi	475	400	340	350
Shore A Hardness	58	55	57	53

TRUCK FUELING HOSE TUBE
Continued

Circ. Air Oven Aging – 70 Hrs. 70°C				
Tensile, psi	2200	2400	2425	2500
% Change	+9	+13	+18	+19
Elongation, %	680	700	710	740
% Change	-6	-7	-11	-8
Shore A Hardness	63	61	64	59
Points Change	+5	+6	+7	+6
Circ. Air Oven Aging – 70 Hrs 100°C				
Tensile, psi	2425	2500	2600	2750
% Change	+20	+18	+26	+31
Elongation, %	570	580	600	610
% Change	-21	-23	-25	-24
Shore A Hardness	75	73	76	71
Points Change	+17	+18	+19	+18
Fluid Aging 48 Hrs. @ 23°C, Fuel B				
Volume Swell, %	+11.4	+13.0	+13.6	+13.1
Fluid Aging 48 Hrs. @ 23°C, Fuel C				
Volume Swell, %	+19.2	+23.6	+26.0	+24.1
Fluid Aging 48 Hrs. @23°C,Shell Unleaded 95%/Methanol 5%				
Volume Swell, %	+24.5	+29.5	+30.5	+32.0
Fluid Aging 48 Hrs.@23°C,Shell Unleaded 74%/Methanol 26%				
Volume Swell, %	+28.3	+32.9	+35.8	+34.1
Gehman Low Temperature Torsion (°C) – Original				
T(2)	-8	-12	-7	-11
T(5)	-15	-19	-15	-17
T(10)	-20	-22	-18	-21
T(100)	-29	-30	-25	-29
Gehman Low Temperature Torsion (°C) – Aged 48 Hrs./Fuel B @ 23°C + Oven Dry @ 70°C				
T(2)	+3	+4	+3	+1
T(5)	-5	-7	-7	-9
T(100)	-18	-17	-15	-18

TRUCK FUELING HOSE TUBE
Continued

Gehman Low Temperature Torsion (°C) – Aged 48 Hrs./Fuel C @ 23°C + Oven Dry @ 70°C				
T(2)	+2	+4	+4	+4
T(5)	-6	-5	-4	-3
T(10)	-9	-8	-7	-7
T(100)	-20	-18	-15	-16
Gehman Low Temperature Torsion (°C) – Aged 48 Hrs. - Shell Unleaded 95%/Methanol 5% @ 23°C + Oven Dry@70°C				
T(2)	+3	+4	+4	+1
T(5)	-5	-5	-6	-6
T(10)	-9	-8	-9	-9
T(100)	-19	-17	-19	-18
Gehman Low Temperature Torsion (°C) – Aged 48 Hrs. - Shell Unleaded 74%/Methanol 26%@23°C + Oven Dry@70°C				
T(2)	+3	+4	+4	+2
T(5)	-5	-4	-4	-5
T(10)	-9	-8	-7	-9
T(100)	-19	-18	-18	-18
Low Temperature Brittleness, Per ASTM D 746(°C)				
Original	-32.5	-32.5	-35.5	-35.5
48 Hrs.@ 23°C,Fuel B	-14.5	-14.5	-14.5	-16.9
48 Hrs.@ 23°C Fuel C	-10.3	-14.5	-14.5	-13.9
48 Hrs. @ 23°C, Shell Unleaded @ 74%/ Methanol 26% + Oven Dry @ 70°C	-17.5	-17.5	-17.5	-17.5
48 Hrs. @ 23°C, Shell Unleaded @ 95%/ Methanol 5% + Oven Dry @ 70°C	-21.1	-22.3	-18.7	-20.5
Low Temperature Retraction – 100% Elongation, Original				
TR-10 (°C)	-21	-21	-19	-22

POLYBLEND FOR FUEL SERVICE

Zeon

Nipol 1203 Rubber		100.0
Dyphos		3.00
Zinc Oxide		3.00
Spider Brand Sulfur		1.5
Stearic Acid		1.0
N-550 Black		25.0
N-990 Black		60.0
DOA		10.0
Metalyn 100		15.0
Atlantic 1115		2.0
Unads		0.3
Altax		1.0
DPG		0.2
Total		**222.0**
Mooney Scorch, Large Rotor, 121°C(250°F)		
Minimum		25
Minutes to 5-point rise		18.75
Minutes to 30-point rise		20.75
Original Properties, Cured 154°C(310°F)	**Minutes Cured**	
Tensile Strength, MPa(psi)	15	11.6(1680)
	30	12.5(1820)
	45	13.2(1910)
200% Modulus, MPa(psi)	15	8.8(1280)
	30	9.4(1370)
	45	10.1(1470)
Elongation, %	15	350
	30	310
	45	310
Durometer A Hardness, pts.	15	73
	30	74
	45	74

POLYBLEND FOR FUEL SERVICE
Continued

Immersions, Samples cured 30 minutes, 154°C(320°F)	
70/30 Iso-octane/toluene, Fuel B 120 hrs., 22°C(72°F) Volume change, %	+14
50/50 Iso-octane/toluene, Fuel C 120 hrs., 22°C(72°F) Volume change, %	+36
50/50 Iso-octane/toluene, Fuel C 168 hrs., 22°C(72°F) Volume change, %	+36
Tubing cured 60 minutes, 154°C(310°F) in steam autoclave	
70/30 Iso-octane/toluene, Fuel B 120 hrs., 22°C(72°F) on 5 cm (2 in.) lengths of tubing Volume change, %	+18

AUTOMOTIVE FUEL SERVICE

Zeon

Nipol 1032 Rubber	100.0
Zinc Oxide	5.0
Spider Brand Sulfur	1.5
Agerite Resin D Antioxidant	2.0
Stearic Acid	1.0
A-C Polyethylene 617	2.0
N-550 Black	25.0
N-991 Black	125.0
DOP	15.0
Flexricin P-4	10.0
MBTS	1.5
TMTD	0.5
Total	**288.5**
Monsanto Rheometer, 170°C(338°F)	
Minimum Torque, M_L, N-m(inch-lbs.)	1.6(14.5)
Maximum Torque, M_H, N-m(inch-lbs.)	5.0(44)
Scorch Time, t_2, min.	2
Optimum Cure, t_{90}, min.	4.8
Garvey Die Extrusion, 3.8 cm.(1.5 in.) NRM, 26 RPM	
Initial Die Temp. °C(°F)	82(180)
Stock Temperature, °C(°F)	99(210)
Final Die Temp., °C(°F)	83(183)
cm/min.(in/min.)	150(59)
g/min.	172
g/cm(g/in)	1.1(2.9)
ASTM D 2230 Rating	15
Swell	3
Edge	4
Surface	4
Corner	4

AUTOMOTIVE FUEL SERVICE
Continued

Original Properties, Cured 10 min. 170°C(338°F)		**Chrysler MS EA-212**
Tensile Strength, MPa(psi)	11.7(1700)	1000 min.
100% Modulus, MPa(psi)	3.9(560)	
Elongation, %	300	250 min.
Durometer A Hardness, pts.	70	60 to 75
Specific Gravity	1.3	
Low Temperature Brittleness, ASTM D 736		
70 Hrs., -40°C(-40°F)	No cracks*	
Compression Set, ASTM Method B, Block, 22 Hrs., 100°C(212°F)		
Cure time, min.	20	
% Set	13	
Air Oven, 70 Hrs., 100°C(212°F)		
Tensile Strength, MPa(psi)	13.6(1980)	
Tensile Change, %	+17	-20 max.
Elongation, %	260	
Elongation Change, %	-13	-40 max.
Durometer A Hardness, pts.	73	
Hardness Change, pts.	+3	
180° Bend	Pass	
ASTM Oil No. 3, 70 Hrs., 100°C(212°F)		
Tensile Strength, MPa(psi)	13.8(2000)	
Tensile Change, %	+18	-35 max.
Elongation, %	260	
Elongation Change, %	-13	-40 max.
Durometer A Hardness, pts.	73	
Hardness Change, pts.	3	
Volume Change, %	3	-5 to 25

*A sample of the hose is to be bent around a mandrel approximately eight times the outside diameter of the hose after 70 hrs. at -40°C(-40°F).

AUTOMOTIVE FUEL SERVICE
Continued

Fuel B, 40 Hrs., 22°C(72°F)		
Tensile Strength, MPa(psi)	10.1(1470)	
Tensile Change, %	-13	
Elongation, %	250	
Elongation Change, %	-17	
Durometer A Hardness, pts.	55	
Hardness Change, pts.	-15	
Volume Change, %	+15	
60% Iso-octane/40% Toluene, 48 hrs., 22°C(72°F)		
Tensile Strength, MPa(psi)	10.3(1500)	
Tensile Change, %	-12	-50 max.
Elongation, %	230	
Elongation Change, %	-23	
Durometer A Hardness, pts.	53	
Hardness Change, pts.	-17	
Volume Change, %	+21	35 max.
Gasoline Extractables Test		
Mg/cm^2 (mg/in^2)	0.05(0.3)	5 max.

AUTOMOTIVE FUEL HOSE COVER
Goodyear

	1	2	3
Chemigum N386B	100.00	100.00	100.00
OXY 200 PVC	45.00	45.00	45.00
Zinc Oxide	5.00	5.00	5.00
Magnesium Oxide	4.00	4.00	4.00
Paraplex G-62	10.00	10.00	10.00
Vanstay FA	1.00	1.00	1.00
Polygard	1.00	1.00	1.00
Hi-Sil 233	10.00	30.00	10.00
Mistron Vapor	50.00	0.00	0.00
N-660 Carbon Black	40.00	40.00	50.00
Wingstay 100	2.00	2.00	2.00
Carbowax 2550	2.00	2.00	2.00
Cumar MH 2- ½(100°C)	7.00	7.00	7.00
Dioctyl Phthalate	20.00	20.00	20.00
Hard Kaolin Clay	20.00	20.00	40.00
Stearic Acid	1.00	1.00	1.00
Calcium Stearate	4.00	4.00	4.00
Hercoflex 900	10.00	10.00	10.00
Sulfur, Spider Brand	0.65	0.65	0.65
Methyl Tuads	1.00	1.00	1.00
Ethyl Tuads	1.00	1.00	1.00
Morfax	1.50	1.50	1.50
Santogard PVI	0.20	0.20	0.20
Total	**336.35**	**306.35**	**316.35**
Rheometer, 193°C, 1° Arc, 100 CPM, 12 Min. Motor			
Torque, Min.	2.6	3.4	2.4
Torque, Max.	14.5	17.4	13.9
TS 1, minutes	1.1	1.0	1.1
T'C90, minutes	2.1	2.1	2.2
Rheometer, 202°C, 1° Arc, 100 CPM, 12 Min. Motor			
Torque, Min.	2.9	3.4	2.4
Torque, Max.	14.7	17.2	13.9
TS 1, minutes	0.9	0.8	0.9
T'C90, minutes	3.1	1.6	4.7

AUTOMOTIVE FUEL HOSE COVER
Continued

ML, 1+4 min./100°C	46	57	46
ML, 1+4 min./121°C	30	38	30
Scorch, ML/121°C			
Minimum	29	38	29
T3, minutes	11.6	9.0	11.4
T5, minutes	12.8	11.4	12.5
Original Properties			
Tensile, Kgm/cm^2	150.6	165.8	154.2
Elongation, %	504	521	530
Hardness, Shore A	73	72	71
Tear, Die-C, Kgm/cm	43.4	43.6	40.5
Tear, Die-B, Kgm/cm	39.6	43.0	37.0
Circ. Air Oven Aging – 70 Hrs. @ 100°C			
Tensile, Kgm/cm^2	163.7	163.7	158.4
% Change	+9	-1	+3
Elongation, %	426	396	410
% Change	-15	-24	-23
Hardness, Shore A	75	75	72
Point Change	+2	+3	+1
Fluid Aging – 48 Hrs. @ 40°C, ASTM Fuel C			
Tensile, Kgm/cm^2	80.2	83.5	70.6
% Change	-47	-50	-54
Elongation, %	468	409	397
% Change	-7	-21	-25
Hardness, Shore A	50	49	47
Point Change	-23	-23	-24
Volume Swell, %	+29.8	+25.2	+27.8
Fluid Aging – 48 Hrs. @ 40°C, Ethanol			
Tensile, Kgm/cm^2	110.4	123.1	102.4
% Change	-27	-26	-34
Elongation, %	475	499	455
% Change	-6	-4	-14
Hardness, Shore A	63	60	59
Point Change	-10	-12	-12
Volume Swell, %	+13.0	+11.6	+11.9

AUTOMOTIVE FUEL HOSE COVER
Continued

Fluid Aging 48 Hrs. @ 40°C,ASTM Fuel C-80%/Ethanol-20%			
Tensile, Kgm/cm^2	67.1	69.8	67.8
% Change	-55	-58	-56
Elongation, %	390	353	375
% Change	-23	-32	-29
Hardness, Shore A	46	45	43
Point Change	-27	-27	-28
Volume Swell, %	+42.6	+43.8	+42.9
Fluid Aging – 70 Hrs. @ 100°C, ASTM Oil No. 3			
Tensile, Kgm/cm^2	155.1	165.8	155.2
% Change	+3	0	+1
Elongation, %	435	455	432
% Change	-14	-13	-18
Hardness, Shore A	76	75	73
Point Change	+3	+3	+2
Volume Swell, %	-1.9	-1.8	-2.7
Specific Gravity	1.364	1.293	1.313
Compression Set – 70 Hrs. @ 100°C, %			
Average	51.8	49.3	50.8
Static Ozone Box @ 50 pphm, 40°C, 20% Elongation – Crack Size/Density			
Rating @ 200 Hrs.	0/0	0/0	0/0
Low Temperature Solenoid Brittleness, Per ASTM D746			
Original (°C)	-17.5	-17.5	-18.7
Aged 48 Hrs. @ 40°C, Fuel C			
-55°C	Pass	Pass	Pass
Aged 48 Hrs. @ 40°C, Ethanol			
-40°C	Pass	Pass	Pass
Solenoid Brittleness Aged 48 Hrs. @ 40°C, ASTM Fuel C – 80%/Ethanol-20%			
-40°C	Pass	Pass	Pass
Aged 72 Hrs. @ 100°C, ASTM Oil No. 3			
Lowest Point (°C)	-14.5	-21.1	-20.5

AUTOMOTIVE FUEL HOSE COVER
Goodyear

	5	6	7
Chemigum N386B	100.00	100.00	100.00
OXY 200 PVC	45.00	45.00	45.00
Zinc Oxide	5.00	5.00	5.00
Magnesium Oxide	0.00	0.00	0.00
Paraplex G-62	15.00	10.00	10.00
Vanstay FA	1.00	1.00	1.00
Polygard	1.00	1.00	1.00
Hi-Sil 233	20.00	30.00	20.00
Mistron Vapor	0.00	0.00	30.00
N-660 Carbon Black	50.00	35.00	30.00
Wingstay 100	2.00	2.00	2.00
Carbowax 2550	2.00	2.00	2.00
Cumar MH 2- ½(100°C)	10.00	10.00	10.00
Dioctyl Phthalate	10.00	10.00	10.00
Hard Kaolin Clay	40.00	0.00	20.00
Stearic Acid	1.00	1.00	1.00
Calcium Stearate	4.00	4.00	4.00
Hercoflex 900	20.00	30.00	20.00
Sulfur, Spider Brand	0.65	0.65	0.65
Methyl Tuads	1.00	1.00	1.00
Ethyl Tuads	1.00	1.00	1.00
Morfax	1.50	1.50	1.50
Santogard PVI	0.20	0.20	0.20
Total	**330.35**	**290.35**	**315.35**
Rheometer, 193°C, 1° Arc, 100 CPM, 12 Min. Motor			
Torque, Min.	3.1	2.5	2.7
Torque, Max.	14.3	14.8	13.2
TS 1, minutes	1.2	1.3	1.2
T'C90, minutes	1.9	2.3	1.9
Rheometer, 202°C, 1° Arc, 100 CPM, 12 Min. Motor			
Torque, Min.	2.6	2.9	3.0
Torque, Max.	13.1	14.3	13.9
TS 1, minutes	1.0	1.0	0.9
T'C90, minutes	1.5	1.6	1.4

AUTOMOTIVE FUEL HOSE COVER
Continued

ML, 1+4 min./100°C	51	46	48
ML, 1+4 min./121°C	34	29	33
Scorch, ML/121°C			
Minimum	32	27	30
T3, minutes	14.4	25.5	19.8
T5, minutes	16.0	29.7	23.0
Original Properties			
Tensile, Kgm/cm^2	146.9	176.2	173.6
Elongation, %	514	572	550
Hardness, Shore A	74	68	72
Tear, Die-C, Kgm/cm	43.9	46.3	44.5
Tear, Die-B, Kgm/cm	39.3	40.0	37.0
Circ. Air Oven Aging – 70 Hrs. @ 100°C			
Tensile, Kgm/cm^2	158.3	179.5	186.6
% Change	+8	+2	+7
Elongation, %	415	464	470
% Change	-19	-19	-15
Hardness, Shore A	75	70	73
Point Change	+1	+2	+1
Fluid Aging – 48 Hrs. @ 40°C, ASTM Fuel C			
Tensile, Kgm/cm^2	79.3	59.3	60.7
% Change	-46	-66	-65
Elongation, %	461	371	408
% Change	-10	-35	-26
Hardness, Shore A	49	45	47
Point Change	-25	-23	-25
Volume Swell, %	+25.6	+26.1	+31.3
Fluid Aging – 48 Hrs. @ 40°C, Ethanol			
Tensile, Kgm/cm^2	106.5	107.4	102.0
% Change	-28	-39	-41
Elongation, %	484	512	494
% Change	-6	-10	-10
Hardness, Shore A	60	59	58
Point Change	-14	-9	-14
Volume Swell, %	+10.1	+8.2	+12.5

AUTOMOTIVE FUEL HOSE COVER
Continued

Fluid Aging 48 Hrs. @ 40°C,ASTM Fuel C-80%/Ethanol-20%			
Tensile, Kgm/cm^2	67.9	50.6	51.1
% Change	-54	-71	-71
Elongation, %	385	315	329
% Change	-25	-45	-40
Hardness, Shore A	43	42	43
Point Change	-31	-26	-29
Volume Swell, %	+37.2	+38.1	+42.8
Fluid Aging – 70 Hrs. @ 100°C, ASTM Oil No. 3			
Tensile, Kgm/cm^2	141.41	165.2	161.5
% Change	-4	-6	-7
Elongation, %	430	495	476
% Change	-16	-13	-13
Hardness, Shore A	73	68	71
Point Change	-1	0	-1
Volume Swell, %	-0.3	0	0
Specific Gravity	1.323	1.241	1.301
Compression Set – 70 Hrs. @ 100°C, %			
Average	51.8	49.0	48.6
Static Ozone Box @ 50 pphm, 40°C, 20% Elongation – Crack Size/Density			
Rating @ 200 Hrs.	0/0	0/0	0/0
Low Temperature Solenoid Brittleness, Per ASTM D746			
Original (°C)	-15.7	-16.9	-15.1
Aged 48 Hrs. @ 40°C, Fuel C			
-55°C	Pass	Pass	Pass
Aged 48 Hrs. @ 40°C, Ethanol			
-40°C	Pass	Pass	Pass
Solenoid Brittleness Aged 48 Hrs. @ 40°C, ASTM Fuel C – 80%/Ethanol-20%			
-40°C	Pass	Pass	Pass
Aged 72 Hrs. @ 100°C, ASTM Oil No. 3			
Lowest Point (°C)	-20.5	-18.1	-14.5

SOUR GASOLINE RESISTANT FUEL HOSE COMPOUND

Goodyear

Chemigum HR665	50.00
Chemigum HR365	50.00
Stearic Acid	0.50
Mistron Vapor Talc	40.00
Hi-Sil EP	40.00
Laminar	35.00
Hi-Sil 215	15.00
Naugard 495	2.00
Irganox MD-1024	1.00
Hercoflex 600	20.00
DSC-18	1.00
MT Black	10.00
Protox 169	5.00
Elastomag 170	10.00
Ethyl Tuads	1.20
Santocure	1.50
Sulfasan R	2.00
Santogard PVI	0.40
Total	**284.60**
Specific Gravity	1.469
ML 212°F/4 minutes	82
Mooney Scorch @ 150°F	
Minimum	32
T3, minutes	19.1
325°F Rheometer Cure	
Torque, Minimum	14.5
Torque, Maximum	82.0
TS 2, minutes	3.3
TC 90, minutes	8.7
325°F Press Cure	10.0
Tensile, psi	1750
Elongation, %	530
300% Modulus, psi	1150
Shore A Hardness	77

SOUR GASOLINE RESISTANT FUEL HOSE COMPOUND Continued

ASTM Reference Fuel C, 48 Hrs. @ R.T.	
Tensile, psi	1175
Elongation, %	400
Shore A Hardness	58
% Volume Swell	23.9
ASTM No. 3 Oil, 70 Hrs. @ 300°F	
Tensile, psi	1550
Elongation, %	460
Shore A Hardness	78
% Volume Swell	+0.7
Gehman, Low Temperature Torsion (°C)	
T2	-11
T5	-17
T10	-20
T100	-30
Indolene HO-111 Sour Gasoline Test Tube Method @ 40°C*	
Tensile, psi	1225
Elongation, %	450
Shore A Hardness	66
Hardness Change	-11

*Fuel adjusted to a 50 peroxide number with t-butyl hydroperoxide. Sour Gasoline changed at 1,2,3, & 7 days physical properties determined at 14 days.

MIL-H-6615B FUEL HOSE
Suitable for year round use in cold climates
Zeon

Nipol 1034-60 Rubber		100.0
Zinc Oxide		5.0
Spider Brand Sulfur		1.5
Stearic Acid		1.0
N-990 Black		130.0
DOA		10.0
MBTS		1.5
Total		**249.0**
Mooney Scorch, Large Rotor, 121°C(250°F)		
Minimum		60
Minutes to 5-point rise		21.5
Minutes to 35-point rise		31
Monsanto Rheometer, 170°C(338°F)		
Minimum Torque, M_L, N-m(inch-lbs.)		4.1(36)
Maximum Torque, M_H, N-m(inch-lbs.)		7.9(70)
Scorch Time, t_2, min.		3.2
Optimum Cure, t_{90}, min.		8.2
Original Properties, Cured 10 min., 170°C(338°F)		
Tensile Strength, MPa(psi)		11.0(1600)
100% Modulus		3.5
Elongation, %		320
Durometer A Hardness, pts.		63
Low Temperature Brittleness, ASTM D 736		**MIL-H-6615B**
72 Hrs., -55°C(-67°F)	Pass	Pass
Immersions		
Ref. Fuel B, 24 Hrs. 22°C(72°F)		
Volume Change, %	+42	+55 Max.
Ref. Fuel B, 48 Hrs., 22°C(72°F)		
Tensile Strength, MPa(psi)	6.1(880)	600 min.
Elongation, %	170	100 min.
Durometer A Hardness, pts.	46	
JP-4 Fuel, 72 Hrs., 22°C(72°F)		
Color Change	Pass	No change
Sediment Contamination	Pass	2 MG/L

MILITARY FUEL & OIL DISCHARGE HOSE TUBE (MIL-H-22240E)

Goodyear

	1	2	3	4
Chemigum N300	100.00	100.00	100.00	100.00
Pepton 22	1.50	1.50	1.50	1.50
N330 (HAF)	60.00	60.00	60.00	60.00
Mistron Vapor	10.00	10.00	10.00	0.00
Zinc Oxide	4.00	4.00	4.00	4.00
Koresin Pellets	10.00	10.00	0.00	5.00
Wingtack 95	0.00	0.00	5.00	5.00
Wingstay 100	1.00	1.00	1.00	1.00
Dibutyl Phthalate	12.00	12.00	12.00	12.00
Cumar MH 2-1/2	0.00	0.00	0.00	5.00
Sulfur, Spider Brand	1.60	1.60	1.60	1.60
TMTM	0.80	0.8	0.80	0.80
Vanfre AP-2	0.00	0.00	2.00	2.00
Molybdenum Disulfide	2.00	0.00	0.00	2.00
Total	**202.90**	**200.90**	**197.90**	**199.90**
Rheometer, 150°C, 3° Arc, 100 CPM, 60 Min. Motor				
Torque, Min.	6.4	6.0	5.6	4.8
Torque, Max.	37.6	36.1	35.1	29.3
T'C 1, minutes	5.6	6.0	7.2	6.4
T'C80, minutes	11.8	12.0	11.9	10.8
T'C90, minutes	19.5	18.3	17.1	16.1
ML-4 Min./100°C	**59.0**	**55.0**	**50.0**	**44.0**
Scorch, MS/100 °C				
Minimum	29.0	27.0	25.0	18.0
20 min. Reading	28.6	27.0	24.6	17.5
SPECIFIC GRAVITY	1.253	1.243	1.242	1.211
Original Physical Properties				
Tensile, psi	3538	3544	3222	3172
Elongation, %	500	505	430	520
Shore A Hardness	81	80	77	78

MILITARY FUEL & OIL DISCHARGE HOSE TUBE (MIL-H-22240E) Continued

Circ. Air Oven Aging – 70 Hrs. 100°C				
Tensile, psi	3652	3589	3468	3391
% Change	+3	+1	+8	+7
Elongation, %	340	330	300	355
% Change	-32	-35	-30	-32
Shore A Hardness	89	88	86	88
Points Change	+8	+8	+9	+10
Fluid Aging – 46 Hrs. @ 23°C, 70% Iso-octane/30% Toluene				
Tensile, psi	2383	2327	2186	1730
% Change	-33	-34	-32	-45
Elongation, %	350	355	310	310
% Change	-30	-30	-28	-40
Shore A Hardness	57	57	60	55
Points Change	-24	-23	-17	-23
Volume Swell, %	+25.2	+25.2	+24.5	+27.0
Gehman Low Temperatuare Torsion				
T(2)	-1	-6	-6	2
T(5)	-14	-15	-17	-12
T(10)	-17	-17	-20	-16
T(100)	-24	-24	-25	-24
Low Temperature Impact Brittleness Per ASTM D 746(°C)	-22.3	-23.5	-26.5	-22.3

INJECTION FUEL HOSES

Enichem

Europrene N 3980		100
Struktol WB 300		15
Octamine		3
ZnO		3
APF N 683		65
Mistron Vapor		40
Ultrasil VN3		15
DOP		15
Sulphur		0.3
Rhenocure S/G		3
Perkacit TBzTD		2
Rhenogran Vulk E-80		0.5
Mooney Compound (1+4) 100°C		65
Scorch at 121°C		
MV	lb*inch	41
T5	min	51
T35	min	59
Rheometer 180°C, 24’, arc ±1°		
TS2	min	2
T90	min	4.5
MH	lb*inch	59
MH-ML	lb*inch	51
Press cure 12 min at 160°C		
M100	MPa	3.6
T.S.	MPa	15.3
E.B.	%	440
Hardness ShA	points	66
Density	g/cm^3	1.34
Ageing in Air 4 days at 100°C		
Δ T.S.	%	13
Δ E.B.	%	-45
Δ ShA	points	18
Ageing in Fuel C 46h at 23°C		
Δ T.S.	%	-12
Δ E.B.	%	-15
Δ ShA	points	-15

**INJECTION FUEL HOSES
Continued**

Ageing in Air 22h at 80°C after Fuel C 46h at 23°C		
Δ T.S.	%	3
Δ E.B.	%	-18
Δ ShA	points	14
Ageing in Diesel Fuel 94h at 23°C		
Δ T.S.	%	-3
Δ E.B.	%	-3
Δ ShA	points	2
Ageing in Air 22h at 80°C after Diesel Fuel 94h at 23°C		
Δ T.S.	%	3
Δ E.B.	%	-15
Δ ShA	points	5
Ageing in FAM 1 46h at 23°C		
Δ T.S.	%	-10
Δ E.B.	%	-2
Δ ShA	points	-3
Ageing in AIR 22h at 80°C after FAM 1 46h at 23°C		
Δ T.S.	%	3
Δ E.B.	%	-11
Δ ShA	points	18
Ageing in FAM 2 46h at 23°C		
Δ T.S.	%	-12
Δ E.B.	%	-3
Δ ShA	points	-3
Ageing in AIR 22h at 80°C after FAM 2 46h at 23°C		
Δ T.S.	%	5
Δ E.B.	%	-10
Δ ShA	points	15

FREON DIFFUSION & OIL/FUEL RESISTANT COMPOUND
Goodyear

Chemigum N206	100.00
Zinc Oxide	5.00
Stearic Acid	0.50
MT Carbon Black	180.00
Paraplex G-53	10.00
Spider Brand Sulfur	1.50
Altax	1.50
Unads	0.20
Total	**298.70**
Original Physical Properties	
Tensile, psi	1400
Elongation, %	270
100% Modulus, psi	1050
Shore A Hardness	88
Specific Gravity	1.430
Compression Set, 70 Hrs. @ 212°F, %	1875
Aged ASTM #3 Oil, 70 Hrs. @ 300°F	
Percent Elongation, % Change	-36
Shore A Hardness, Points Change	+2
% Volume Change	+1.9
Freon Diffusion Rate	
cc/Sq. In/Day	1.36
Aged in Liquified Freon 12, 70 Hrs. @ R.T.	
Linear Change, %	0.0
Weight Change, %	0.88

POWER STEERING HOSE
Enichem

Europrene N3345		100
ZnO		5
Stearic acid		1
Suprex Hard Clay		15
N 762 SRF		30
N 550 FEF		45
Anox HB		2
Vulkanox MB2		2
DOP		10
Santocure MOR		3
TMTD		1
Sulfasan R		2.5
T.S.	MPa	17
E.B.	%	320
Hardness ShA	points	70
Compression set 70h 120°C	%	20
Ageing in Air 70h at 120°C		
Δ T.S.	%	5
Δ E.B.	%	-25
Δ ShA	points	7
Ageing in ASTM #3 oil 70h at 100°C		
Δ T.S.	%	-2
Δ E.B.	%	-10
Δ ShA	points	-5
Δ Volume	%	7
Ageing in power steering oil 70h at 100°C		
Δ T.S.	%	4
Δ E.B.	%	-18
Δ ShA	points	-1
Δ Volume	%	0.5

AIR INTAKE HOSE

Enichem

Europrene N OZO 7039		100
ZnO		3
Stearic acid		1
Struktol WB 900		5
Ultrasil VN3		10
Black N 772 SRF		40
Mistron Vapor		35
Vulkanol OT		10
Santicizer 409A		15
Riowax 721		3
Vulkanox 4010NA		3
Anox HB		1.5
Vulkanox MB2		1.5
MBTS		1.5
TMTD		2.5
DTDM		2.5
Sulphur		0.2
Mooney Compound (1+4) 100°C		48
Scorch at 121°C		
MV	lb*inch	25
T5	min	22.4
T35	min	30.0
Rheometer 160°C, 24’, arc ±1°		
ML	lb*inch	1.8
MH	lb*inch	21.4
TS1	min	3.4
T50	min	5.0
T90	min	6.5
Press cure 8 min at 160°C		
T.S.	MPa	11.5
E.B.	%	400
Hardness ShA	points	76
Tear resistance	N/mm	47
Compression set 22h 100°C	%	40
TR test		
TR 10	°C	-10

AIR INTAKE HOSE
Continued

Ageing in Air 168h at 100°C		
Δ T.S.	%	15
Δ E.B.	%	-38
Δ ShA	points	8
Ageing in Fuel C 70h at 23°C		
Δ T.S.	%	-45
Δ E.B.	%	-16
Δ ShA	points	-22
Δ Volume	%	28

EMISSION CONTROL HOSE TUBE

Uniroyal

Paracril® BJLT-HX	100.0	
Zinc Oxide	5.0	
Aminox®	1.0	
ZMTI	2.0	
Naugard® 445	1.0	
Hi Sil 532 EP	50.0	
N-550 Black	10.0	
Stearic Acid	1.0	
TE-80	2.0	
Plasticizer SC	5.0	
Tuex®	3.5	
Delac® S	2.0	
Spider Sulfur	0.25	
Monsanto PVI	0.4	
Paraplex G-25	5.0	
Total	**188.15**	
	A	**ESE-M2D147A Requirements**
Unaged Physical Properties Cured 30 Minutes @ 160°C(320°F)		
Tensile Strength, MPa (psi)	13.2(1920)	8.0(1200) Minimum
Elongation, %	440	300 Min.
200% Modulus, MPa (psi)	4.1(590)	----
Hardness, Shore A	67	60 – 75
Oven Aged 70 Hours @ 125°C(257°F)		
Tensile Strength, MPa (psi)	12.1(1760)	
Tensile Strength, % Change	-8	-20 Max.
Elongation, %	440	
Elongation, % Change	0	-50 Max.
Hardness, Shore A	78	
Hardness, Points Change	+11	+15 Max.

EMISSION CONTROL HOSE TUBE
Continued

Aged 70 Hours @ 149°C(300°F), ASTM #3 Oil		
Tensile Strength, MPa (psi)	13.0(1890)	
Tensile Strength, % Change	-2	-40 Max.
Elongation, %	600	
Elongation, % Change	+36	-40 Max.
Hardness, Shore A	50	
Hardness, Points Change	-17	
Volume Swell, %	+12	-5 to +25
Brittle Point, °C(°F)	-30(-22)	
Compression Set, 70 Hours @ 135°C(275°F)		
Method B Plied Discs, %	35.5	

AUTOMOTIVE AIR CONDITIONING HOSE

Zeon

	1	2
Nipol 1051 Rubber	100.0	50.0
Nipol 1053 Rubber	----	50.0
Zinc Oxide	5.0	5.0
Spider Brand Sulfur	0.5	0.5
Agerite Resin D Antioxidant	2.0	2.0
Stearic Acid	1.0	1.0
N-991 Black	147.0	147.0
N-550 Black	29.0	29.0
Sulfasan R	2.3	2.3
CBTS	1.0	1.0
Paraffin Wax	3.0	3.0
Total	**290.8**	**290.8**
Mooney Scorch, Large Rotor, 132°C(270°F)		
Minimum	63	72
Minutes to 5-point rise	9	14
Minutes to 35-point rise	12	19
Original Properties, Sheets Cured 25 minutes, 157°C(315°F)		
Tensile Strength, MPa(psi)	11.6(1680)	14.3(2070)
100% Modulus, MPa (psi)	7.0(1020)	8.1(1180)
Elongation, %	280	230
Durometer A Hardness, points	83	80
Compression Set, ASTM Method B, Buttons, Cured 25 min. 157°C(315°F)		
70 Hrs, 100°C (212°F)	63	52
Low Temperature Brittleness, ASTM D 746		
Pass, °C(°F)	-10(+14)	-20(-4)
Fail, °C(°F)	-15(+5)	-25(-13)
Tb, °C(°F)	-14(+7)	-24(-11)
Low Temperature Brittleness, ASTM D 736		
Pass, °C(°F)	-29(-20)	-46(-50)
Fail, °C(°F)	-34(-30)	-51(-60)
Gas Transmission Rate (GTR), cm^3,mm/m^2, 24 hr atm		
(cm^3 mil/100 in^2, 24 hr atm)		
Freon 12	14.4(36.66)	15.0(38.00)

POWER STEERING SERVICE
Zeon

Nipol 1032 Rubber	100.0
Cadmium Oxide	5.0
Stan-Mag Beads	10.0
Stearic Acid	1.0
Naugard 445	4.0
Hi-Sil 233	50.0
Silane A-189	1.0
Paraplex G-41	10.0
Ethyl Cadmate	2.5
MBTS	2.0
Sulfasan R	2.0
Total	**187.5**
Mooney Scorch, Large Rotor, 121°C(250°F)	
Minimum	63
Minutes to 5-point rise	14
Minutes to 35-point rise	21.4
Monsanto Rheometer, 177°C(350°F), 900 CPM, 3° Arc, Square Die	
Minimum Torque, M_L, N-m(inch-lbs.)	3.1(27)
Maximum Torque, M_H, N-m(inch-lbs.)	11.1(104)
Scorch Time, t_2, min.	2.5
Optimum Cure, t_{90}, min.	6.5
Original Properties, Sheets Cured 10 min., 177°C(350°F)	
Tensile Strength, MPa(psi)	13.4(1950)
100% Modulus, MPa (psi)	2.9(420)
200% Modulus, MPa(psi)	8.3(1200)
Elongation, %	280
Durometer A Hardness, pts.	68
Compression Set, ASTM D 395, Method B, plied disks	
70 Hrs., 150°C(302°F), %	67
70 Hrs., 125°C(257°F), %	35
Low Temperature Brittleness, ASTM D 746	
Pass, °C(°F)	-20(-4)
Fail, °C(°F)	-25(-13)
T_b, °C(°F)	-24.5(-12.1)
Specific Gravity	1.23

POWER STEERING SERVICE
Continued

ASTM Oil No. 1, Aged 168 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	16.7(2420)
Tensile Change, %	+24
Elongation, %	2.4(350)
Elongation Change, %	+25
Shore A Hardness, pts.	72
Hardness Change, pts.	+4
Volume Change, %	-5.2
180° Bend	Pass
ASTM Oil No. 3, Aged 168 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	14.8(2150)
Tensile Change, %	+10
Elongation, %	380
Elongation Change, %	+36
Shore A Hardness, pts.	55
Hardness Change, pts.	-13
Volume Change, %	+13
180° Bend	Pass
Air Test Tube, Aged 70 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	16.9(2450)
Tensile Change, %	+26
Elongation, %	410
Elongation Change, %	+46
Shore A Hardness, pts.	70
Hardness Change, pts.	+2
180° Bend	Pass
Air Test Tube, Aged 168 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	12.0(1740)
Tensile Change, %	-11
Elongation, %	180
Elongation Change, %	-36
Shore A Hardness, pts.	80
Volume Change, %	+12
180° Bend	Pass

POWER STEERING SERVICE
Continued

Power Steering Fluid (Texaco TL 4634), Aged 168 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	9.2(1330)
Tensile Change, %	-32
Elongation, %	250
Elongation Change, %	-11
Shore A Hardness, pts.	62
Hardness Change, pts.	6
Volume Change, %	+5.3
180° Bend	Pass

Kendall Dexron II D-ATF Fluid, Aged 168 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	10.8(1570)
Tensile Change, %	-19
Elongation, %	270
Elongation Change, %	-4
Shore A Hardness, pts.	68
Hardness Change, pts.	0
Volume Change, %	+2.3
180° Bend	Pass

AIR, OIL AND WATER SERVICE
Zeon

Nipol 1032 Rubber	50.0
Ameripol 1503 SBR	50.0
Zinc Oxide	5.0
Spider Brand Sulfur	0.5
Agerite White Antioxidant	0.5
Agerite Resin D Antioxidant	2.0
Stearic Acid	1.0
N-550 Black	20.0
N-990 Black	40.0
Atomite	40.0
Flexol 4G0	10.0
Resinex 100	10.0
Paraffin Wax	2.0
Diethylene Glycol	2.0
TMTD	1.5
Sulfasan R	1.5
Total	**236.0**
Original Properties, Cured 10 min., 170°C(338°F)	
Tensile Strength, MPa(psi)	8.5(1230)
300% Modulus, MPa(psi)	4.4(640)
Elongation, %	560
Durometer A Hardness, points	60
Compression Set, ASTM Method B, Block Cured 20 min., 170°C(338°F) 70 Hrs., 100°C(212°F), %	24
Immersions – All cured 10 min., 170°C(338°F)	
Air Test Tube, 70 Hrs., 100°C(212°F)	
Tensile Strength, MPa(psi)	7.8(1130)
Tensile change, %	-8
Elongation, %	480
Elongation change, %	-14
Durometer A Hardness, pts.	65
Hardness change, pts.	+5
180° Bend	Pass

AIR, OIL AND WATER SERVICE
Continued

Distilled Water, 70 Hrs., 100°C(212°F)	
Tensile Strength, MPa(psi)	7.7(1120)
Tensile change, %	-9
Elongation, %	500
Elongation change, %	-11
Durometer A Hardness, pts.	60
Hardness change, pts.	0
Volume change, %	+2
180° Bend	Pass

GENERAL PURPOSE HYDRAULIC SERVICE

Zeon

Nipol 1072 Rubber	80.0
Ameripol 1501 SBR	20.0
Sulfur	0.75
Agerite Resin D Antioxidant	2.0
Stearic Acid	1.0
FEF Black	55.0
Hycar 1312 Rubber	5.0
TMTD	3.0
Zinc Oxide	5.0
Total	**171.75**
Mooney Scorch, Large Rotor, 121°C(250°F)	
Minimum Mooney	49.5
Minutes to 5-point rise	8.5
Minutes to 30-point rise	13.5
Original Properties, Cured 10 min., 170°C(338°F)	
Tensile Strength, MPa(psi)	22.5(3270)
100% Modulus, MPa(psi)	11.2(1620)
Elongation, %	250
Durometer A Hardness, pts.	85
Specific Gravity	1.19
Compression Set, ASTM Method B, Block Cured 20 min. 170°C(338°F), 70 Hrs., 125°C(257°F), %	32
Compression Set, ASTM Method B, plied disks, samples cured 10 min., 170°C(338°F)	
70 Hrs., 125°C(257°F), %	40
Low Temperature Brittleness, ASTM D 736	
5 Hrs., -40°C(-40°F)	Pass
Samples Cured 10 min., 170°C(338°F)	
ASTM Oil No. 1, Aged 70 Hrs., 125°C(257°F)	
Volume Change, %	+4
ASTM Oil No. 3, Aged 70 Hrs., 125°C(257°F)	
Volume Change, %	+33

GENERAL PURPOSE HYDRAULIC SERVICE
Continued

Gulf SAE 30 Motor Oil, Aged 168 Hrs., 125°C(257°F)	
Tensile Change, %	-20
Elongation Change, %	-60
Hardness Change, pts.	-1
Volume Change, %	+12
180° Bend	Pass

HIGH TEMPERATURE HYDRAULIC SERVICE

Zeon

Nipol 1042 Rubber	30.0
Nipol 1043 Rubber	70.0
Zinc Oxide XX78	5.0
Stan-Mag Beads	5.0
Stearic Acid	1.0
Naugard 445	3.0
Ni-Sil 233	30.0
Hi-Sil EP	20.0
Silane A-189	0.4
Paraplex G-41	10.0
TE-80	1.0
CBTS	1.75
Sulfasan R	1.1
Pennac TM	1.25
Total	**180.50**
Mooney Scorch, Large Rotor, 121°C(250°F)	
Minimum Mooney	57
Minutes to 5-point rise	18
Minutes to 30-point rise	30.3
Monsanto Rheometer, 177°C(350°F) 900 CPM, 3° Arc, Square Die	
Minimum Torque, M_L, N-m(inch-lbs.)	2.8(25)
Maximum Torque, M_H, N-m(inch-lbs.)	9.0(80)
Scorch Time, t_2, min.	3.5
Optimum Cure, t_{90}, min.	9.5
Original Properties, Sheets Cured 12 min., 177°C(350°F)	
Tensile Strength, MPa(psi)	16.7(2420)
100% Modulus, MPa(psi)	1.9(280)
Elongation, %	520
Durometer A Hardness, pts.	61
Hardness 1 RHD, pts.	66
Specific Gravity	1.21
Compression Set, ASTM D 395, Method B, plied disks	
22 Hrs., 150°C(302°F), %	54

HIGH TEMPERATURE HYDRAULIC SERVICE Continued

ASTM Oil No. 1, Aged 70 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	17.4(2520)
Tensile Change, %	+4
Elongation, %	530
Elongation Change, %	+2
Hardness 1 RHD, pts.	74
Hardness Change, pts.	+8
Volume Change, %	-2.2
180° Bend	Pass
ASTM Oil No. 3, Aged 70 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	13.9(2020)
Tensile Change, %	-17
Elongation, %	520
Elongation Change, %	0
Hardness 1 RHD, pts.	50
Hardness Change, pts.	-16
Volume Change, %	+26
180° Bend	Pass
Air Oven, Aged 70 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	12.6(1830)
Tensile Change, %	-24
Elongation, %	500
Elongation Change, %	-4
Hardness 1 RHD, pts.	77
Hardness Change, pts.	+10
180° Bend	Pass

OIL SUCTION AND DISCHARGE SERVICE

Zeon

Nipol 1041 Rubber		100.0
Zinc Oxide		5.0
Agerite Superflex Antioxidant		5.0
Spider Brand Sulfur		0.2
Stearic Acid		1.0
FEF Black		30.0
HAF Black		20.0
DOP		5.0
Methyl Tuads		3.0
Total		**169.2**
Mooney Scorch, Large Rotor, 121°C(250°F)		
Minimum		43.5
Minutes to 5-point rise		14.5
Minutes to 30-point rise		24
Original Properties	**Min. Cured, 166°C(330°F)**	
Tensile Strength, MPa(psi)	5	20.6(2990)
	10	21.6(3140)
	20	22.0(3190)
300% Modulus, MPa(psi)	5	9.9(1430)
	10	11.2(1620)
	20	11.2(1620)
Elongation, %	5	650
	10	600
	20	600
Durometer A Hardness, pts.	5	67
	10	67
	20	67
Compression Set, ASTM Method B, Block Cured 20 min.		
22 Hrs., 100°C(212°F), % Set		15
Tear Resistance, ASTM D 624, Die B, Cured 10 min.		
with grain, kN/m(ppi)		62.3(390)

OIL SUCTION AND DISCHARGE SERVICE
Continued

ASTM Oil No. 1, Aged 70 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	22.7(3290)
Tensile Change, %	+5
Elongation, %	400
Elongation Change, %	-33
Durometer A Hardness, pts.	75
Hardness Change, pts.	+8
Volume Change, %	-8
ASTM Oil No. 3, Aged 70 Hrs., 150°C(302°F)	
Tensile Strength, MPa(psi)	19.8(2880)
Tensile Change, %	-8
Elongation, %	400
Elongation Change, %	-33
Durometer A Hardness, pts.	63
Hardness Change, pts.	-4
Volume Change, %	+5
Air Test Tube, Aged 70 Hrs., 125°C(257°F)	
Tensile Strength, MPa(psi)	22.9(3330)
Tensile Change, %	+6
Elongation, %	410
Elongation Change, %	-32
Durometer A Hardness, pts.	73
Hardness Change, pts.	+6

HOSE FORMULAS

Zeon

A-020-111	1	2	3
Nipol AR-72HF	100.00	75.00	----
Nipol AR-74	----	25.00	----
Hy Temp AR-72LF	----	----	100.00
Stearic Acid	1.00	1.00	1.00
Struktol WB222	2.00	2.00	2.00
Naugard 445	2.00	2.00	2.00
N-330 Black	40.00	40.00	40.00
N-550 Black	40.00	30.00	40.00
TP-759	8.00	----	8.00
Vulkalent E/C	0.30	0.30	0.30
Hy Temp ZC-50	5.00	5.00	5.00
Total	**198.30**	**180.30**	**198.30**
Processing Properties			
Mooney Viscometer			
ML(1+4) @ 100°C	51	56	45
ML(1+35) @ 125°C	42	46	36
T5, mins.	25.2	23.9	28.6
T35, mins.			
Rheometer, 100 CPM, 3° Arc, 190°C			
ML, lb-in	16.5	10.9	11.3
MH, lb-in	57.5	53.1	56.2
Ts2, min.	2.6	2.5	2.2
T90, min.	11	10.7	9.1
Cure Time, mins.	4	4	4
Original Physicals, Cured 4 mins @ 190°C			
100% Modulus, MPa(psi)	2.8(401)	4.0(583)	3.2(465)
200% Modulus, MPa(psi)	6.1(882)	8.5(1233)	6.4(935)
Tensile Strength, MPa(psi)	8.8(1271)	11.1(1616)	8.3(1208)
Elongation, %	418	351	348
Hardness, Shore A	64	61	66
Post Cured Physicals, Post Cured 4 Hrs. @ 180°C			
100% Modulus, MPa(psi)	3.6(521)	4.8(700)	4.7(676)
200% Modulus, MPa(psi)	8.1(1178)	10.3(1500)	9.2(1340)
Tensile Strength, MPa(psi)	9.9(1434)	12.1(1758)	9.9(1440)
Elongation, %	310	281	248
Hardness, Shore A	68	67	70

HOSE FORMULAS
Continued

Compression Set, Post Cured, Buttons, Aged 70 Hrs. @ 150°C			
Set, %	18	24	27
Tear, Die "T", ppi	26	21.6	22.8
Tear, Die "T", kN/m	4.6	3.8	4.0
Gehman Low Temperature Torsion			
Original Angle, °	168	169	168
T2, °C	-2.5	-0.3	-2.5
T5, °C	-16.4	-14.4	-19.4
T10, °C	-22.7	-20.7	-23.9
T100, °C	-33.7	-30.3	-34
Aged: Air Oven, 168 Hrs. @ 150°C			
Tensile Strength (% Change)	1465(2%)	1764(0%)	1423(-1%)
Elongation (% Change)	244(-21%)	246(-12%)	184(-26%)
Hardness (Points Change)	80(12)	76(9)	80(10)
Aged: Diesel Fuel, 46 Hrs. @ 23°C			
Tensile Strength (% Change)	1482(3%)	1530(-13%)	1455(1%)
Elongation (% Change)	268(-14%)	249(-11%)	261(5%)
Hardness (Points Change)	57(-11)	56(-11)	57(-13)
Volume Change, %	9	11	9
Aged: BP 4437 Motor Oil, 94 Hrs. @ 150°C			
Tensile Strength (% Change)	1732(21%)	1841(5%)	1702(18%)
Elongation (% Change)	271(-13%)	231(-18%)	256(3%)
Hardness (Points Change)	66(-2)	64(-3)	66(-4)
Volume Change, %	0	4	0

LIQUID PETROLEUM GAS SERVICE
Zeon

Nipol 1032 Rubber	100.0
Zinc Oxide	5.0
Stearic Acid	1.0
Spider Brand Sulfur	1.5
Conductive N-472 Black	80.0
N-990 Black	40.0
Santicizer 141	48.0
MBTS	1.5
Total	**277.0**
Mooney Scorch, Large Rotor, 121°C(250°F)	
Minimum	72
Minutes to 5-point rise	20
Minutes to 30-point rise	30
Minutes to 31 minutes	72
Garvey Die Extrusion – No. ½ Royle Extruder at 25 RPM	
Head Temperature Start, °C(°F)	82(180)
Head Temperature Finish, °C(°F)	90(194)
Stock Temperature, °C(°F)	105(222)
cm/min. (in/min.)	66(26)
g/min.	48
g/cm(g/in.)	0.73(1.85)
Appearance rating:	
Contour	4
Corner	4
Edge	4
Surface	4
Original Properties, Cured 10 min., 170°C(338°F)	
Tensile Strength, MPa(psi)	7.4(1070)
100% Modulus, MPa(psi)	2.4(350)
300% Modulus, MPa(psi)	6.5(950)
Elongation, %	400
Durometer A Hardness, pts.	70

LIQUID PETROLEUM GAS SERVICE
Continued

Low Temperature Testing, 24 Hrs., -40°C(-40°F)	
1.3 x 20.3 cm(0.5 x 8 in.) strip from hose wrapped around 0.64 cm (0.25 in.) mandrel	Pass
Tubing Extrusion Rapid Bending	Pass
Hexane Immersion, 24 hrs., 22°C(72°F)	
Volume Change, %	+2
Oxygen Bomb Aging, 96 hrs., 70°C(158°F), 2.1 MPa (300 psi)	
Tensile Strength, MPa (psi)	11.0(1590)
Tensile Change, %	+48
Elongation, %	280
Elongation Change, %	-30
Electrical Conductivity	
2.5 x 12.7 cm (1 x 5 in.) strip, ohms resistivity	200
1.6 cm (0.63 in.) tube, ohms resistivity	3000

LPG HOSE
Enichem

Europrene N 3345		90
Europrene 1502		10
ZnO		5
Stearic acid		1
N 762 SRF		25
N 990 MT		25
Mesamoll		15
Vulkanox MB2		2
Flectol H		2
MBTS		1.5
TMTM		1.5
Sulphur		1.5
Press cure 5 min at 180°C		
T.S.	MPa	9.4
E.B.	%	560
Hardness ShA	points	46
Compression set 70h 120°C	%	22
Bending test (-20°C)		Pass
Ageing in ASTM #2 oil 7 days at 100°C		
Δ ShA	points	4
Δ Weight	%	-6
Ageing in Pentane 7 days at 23°C		
Δ T.S.	%	-18
Δ ShA	points	0
Δ Weight	%	4

LPG RESISTANT HOSE
Enichem

		1	2	3
Europrene N 3345		100	100	100
ZnO		5	5	5
Stearic acid		1	1	1
N 762 SRF		30	60	70
N 990 MT		30	-	70
Mesamoll		10	10	-
DOP		7.5	-	5
Vulkanox MB2		2.5	2.5	2.5
Anox HB		1	1	1
Trigonox 29/40		6.5	6.5	6.5
Press cure 15 min at 155°C				
Hardness ShA	points	50	60	83
Compression set 70h 100°C	%	15	16	18
Brittle point	°C	-38	-36	-35
Ageing in Pentane 72h at 23°C				
Δ Volume	%	7	6	3
Ageing in Pentane 100h at 23°C				
Δ Volume	%	2	2	5.5
Ageing in Air 100h at 110°C				
Δ Volume	%	3	4	2

FIRE HOSE COVER

DSM

	1	2	3	4
Nysyn 305V	143.0	143.0	143.0	143.0
Cyprubond	100.0	80.0	80.0	100.0
Plasthall 7050	10.0	10.0	20.0	20.0
Plasticizer MT-511	10.0	20.0	10.0	20.0
Flexzone 6H	0.5	0.5	0.5	0.5
Zinc Oxide	5.0	5.0	5.0	5.0
Stearic Acid	0.5	0.5	0.5	0.5
Aminox	2.0	2.0	2.0	2.0
Sartomer C-7000	1.0	1.0	1.0	1.0
MBTS	1.0	1.0	1.0	1.0
TMTD	0.5	0.5	0.5	0.5
Spider Sulfur	1.0	1.0	1.0	1.0
DPG	0.8	0.8	0.8	0.8
TMTM	0.5	0.5	0.5	0.5
DTDM	0.5	0.5	0.5	0.5
Ultramarine Blue	0.1	0.1	0.1	0.1
Titanium Dioxide	1.5	1.5	1.5	1.5
Desical P	4.0	4.0	4.0	4.0
Total	281.9	271.9	271.9	301.9
Physical Properties				
Compound Viscosity				
ML (1+4) 100°C	78	71	48	40
Mooney Scorch @ 132°C				
Min. to 5 Pt. Rise	1.8	1.1	2.2	2.8
Minimum Reading	39	39	24	22
Press Cured @ 150°C, 10 min. cure				
Tensile, MPa	13.5	11.0	11.6	10.3
Elongation, %	350	330	430	460
100% Modulus, MPa	6.6	5.4	4.0	4.0
200% Modulus, MPa	9.7	8.2	6.1	5.5
300% Modulus, MPa	12.1	10.3	7.9	6.9
Hardness, Shore A	80	75	75	75
After Air Oven Aging 70 hrs. @ 100°C, 10 min. cure				
Tensile, % Change	+12	-2	+16	+10
Elongation, % Change	-20	-33	-21	-33
Hardness, Pts. Change	+6	+10	+3	+5

FIRE HOSE COVER
Continued

After Immersion in ASTM Oil #1, 70 Hrs. @ 100°C, 10 min. cure				
Tensile, % Change	+24	-5	+10	+13
Elongation, % Change	-26	-39	-26	-24
Hardness, Pts. Change	+11	+8	+5	+8
Volume Change, %	-2.4	-2.4	-5.1	-4.7
After Immersion in ASTM Oil #3, 70 Hrs. @ 100°C, 10 min. cure				
Tensile, % Change	-3	-3	+13	+3
Elongation, % Change	-20	-30	-19	-28
Hardness, Pts. Change	0	-3	+7	+3
Volume Change, %	+11	+10	+6	+6
After Immersion in ASTM Fuel B, 70 Hrs. @ 23°C, 10 min. cure				
Tensile, % Change	-44	-47	-46	-48
Elongation, % Change	-29	-39	-42	-39
Hardness, Pts. Change	-18	-22	-15	-15
Volume Change, %	+30	+30	+26	+18
After Immersion in ASTM Fuel C, 70 Hrs. @ 23°C, 10 min. cure				
Tensile, % Change	-58	-55	-54	-55
Elongation, % Change	-43	-55	-49	-43
Hardness, Pts. Change	-25	-22	-23	-23
Volume Change, %	+52	+48	+37	+39
Ozone Resistance, 70 Hrs. @ 40°C, 50 pphm				
Passed = P	P	P	P	P

HOSE FOR LOW TEMPERATURE RESISTANCE

Enichem

Europrene N 1945 GRN		40
Europrene N 2845		60
ZnO		5
Stearic acid		1
N 550 FEF		40
N 330 HAF		50
Calcium Carbonate		50
Vulkanol 85		20
DOP		20
Flectol H		1.5
Vulkanox 4010 NA		1.5
MBTS		1.5
TMTM		0.2
Sulphur		1.5
Press cure 5 min at 165°C		
T.S.	MPa	13.5
E.B.	%	370
Hardness ShA	points	65
Tear resistance	N/mm	42
Brittle point	°C	-43
Ageing in ASTM #3 oil 70h at 100°C		
Δ T.S.	%	0
Δ E.B.	%	-30
Δ ShA	points	4
ΔVolume	%	3
Ageing in Air 70h at 100°C		
Δ T.S.	%	0
Δ E.B.	%	-38
Δ ShA	points	11

HIGH PRESSURE HOSES
Different hardness
Enichem

		1	2	3	4
Europrene N 3360		90	90	90	90
Intol 1500		10	10	10	10
ZnO		5	5	5	5
Stearic acid		1	1	1	1
N 772 SRF		20	70	75	90
N 550 FEF		20	10	25	25
N 990 MT		20	20	30	50
DOP		20	20	20	15
Vulkanox MB2		1.5	1.5	1.5	1.5
Flectol H		1.5	1.5	1.5	1.5
Coumarone resin		3	3	5	7
Dispergum N		-	2	5	7
MBTS		2	2	2	2
TMTD		2.5	2.5	2.5	2.5
Sulphur		0.3	0.3	0.3	0.3
Press cure 10 min at 150°C					
T.S.	MPa	12	12.5	11.5	12
E.B.	%	540	350	280	260
Hardness ShA	points	53	64	73	83
Tear resistance	N/mm	32	51	38	40
Compression set 70h 100°C	%	25	21	21	18
Ageing in Air 70h at 100°C					
Δ T.S.	%	2	7	14	-1
Δ E.B.	%	-26	-14	-21	-35
Δ ShA	points	7	5	6	4
Ageing in ASTM #1 oil 70h at 100°C					
Δ T.S.	%	10	11	18	7
Δ E.B.	%	-19	-20	-33	-30
Δ ShA	points	5	6	6	3
Δ Volume	%	-4	-4	-3	-4
Ageing in ASTM #3 oil 70h at 100°C					
Δ T.S.	%	3	7	16	2
Δ E.B.	%	-22	-6	-33	-35
Δ ShA	points	0	-1	-3	-5
Δ Volume	%	5	4	6	4

MILK HOSE
Enichem

Europrene N2860		100
ZnO		1
Stearic acid		3
Silteg AS7		25
Calcium carbonate		80
N 772 SRF		20
DOA		5
Vulkanox BKF		2
Vaselin oil		2
Titanium dioxide		4
Rhenocure S/G		1.5
Perkacid TBzTD		1
Sulphur		0.5
Mooney Compound (1+4) 100°C		90
Scorch at 121°C		
MV	lb*inch	75
T5	min	8.2
T35	min	9.6
Rheometer 180°C, 24’, arc ± 1°		
ML	lb*inch	10.4
MH	lb*inch	31.4
TS1	min	0.8
T50	min	1.0
T90	min	3.0
Press cure 2 min at 180°C		
M100	MPa	1.0
M300	MPa	2.0
T.S.	MPa	8.2
E.B.	%	840
Hardness ShA	points	57
Compression set 70h 100°C	%	60

HOSE /BELT COVER FOR -40°C SERVICE
Goodyear

Chemigum N917	100.00
OXY 200 PVC Resin	43.00
Zinc Oxide	5.00
Polygard	1.00
Paraplex G-62	5.00
Vanstay 9100	1.00
Silene D	40.00
Soft Clay	20.00
N-762 Carbon Black	40.00
Wingstay L	2.00
Stearic Acid	1.00
Carbowax 3350	1.00
Triethanolamine DLC	0.50
Santicizer 261	1st pass 20.00
Sulfur, Spider Brand	0.65
Methyl Tuads	1.00
Ethyl Tuads	1.00
Morfax	1.50
Santogard PVI	2nd Pass 0.20
Total	**283.85**
Rheometer, 163°C, 3° Arc, 100 CPM, 60 Min. Motor	
Torque, Min.	10.8
Torque, Max.	60.3
TS 2	3.1
T'C90, minutes	7.4
T'C95, minutes	19.0
Rheometer, 171°C, 3° Arc, 100 CPM, 60 Min. Motor	
Torque, Min.	9.8
Torque, Max.	56.3
TS 2	2.5
T'C90, minutes	6.0
T'C95, minutes	27.5

HOSE /BELT COVER FOR -40°C SERVICE
Continued

Mooney Scorch, MS/250°F	
Minimum	26.0
20 Min. Reading	27.9
Specific Gravity	1.285
Compression Set, Method B (Buttons)	
22 Hrs./100°C	30.4
70 Hrs./100°C	36.5
Tear	
Die (B), ppi	274
Die (C), ppi	189
Original Physical Properties – Cure 10’ @ 171°C	
Tensile, psi	1825
Elongation, %	410
100% Modulus, psi	575
200% Modulus, psi	1000
300% Modulus, psi	1400
Shore A Hardness	79
Air Test Tube Aged 70 Hrs. @ 100°C	
Tensile, psi	1875
% Change	+3
Elongaiton, %	360
% Change	-12
Shore A Hardness	81
Points Change	+2
Air Test Tube Aged 166 Hrs. @ 100°C	
Tensile, psi	1850
% Change	+1
Elongaiton, %	330
% Change	-21
Shore A Hardness	82
Points Change	+3

HOSE /BELT COVER FOR -40°C SERVICE
Continued

Fluid Aging 48 Hrs. @ 23°C, 80/20 Fuel C/Methanol	
Tensile, psi	775
% Change	-58
Elongaiton, %	250
% Change	-39
Shore A Hardness	45
Points Change	-34
% Volume Change	+79.0
Fluid Aging 72 Hrs. @ 23°C, 80/20 Fuel C/Methanol	
Tensile, psi	750
% Change	-59
Elongaiton, %	250
% Change	-39
Shore A Hardness	46
Points Change	-33
% Volume Change	+77.0
Gehman Low Temp. Torsion – Original (°C)	
T(2)	-1
T(5)	-11
T(10)	-18
T(100)	-40
Gehman Low Temp. Torsion – Conditioned*(°C)	
T(2)	8
T(5)	-4
T(10)	-13
T(100)	-55
Low Temperature Impact Brittleness, Per ASTM D 746 (°C)	
Original	-42.5
Conditioned*	-41.3
Tear	
Die (B), ppi	274
Die (C), ppi	189

*Fluid Immersion 48 Hrs. @ 23°C in 80/20 – Fuel C/Methanol, then dry-out 1 day @ 23°C, then 1 hr. @ 70°C

HOSE /BELT COVER FOR -40°C SERVICE Continued

Static Ozone Box 100 pphm @ 49°C, With 15% Extension – Density/Size	
24 Hrs.	0/0
96 Hrs.	0/0
120 Hrs.	0/0
144 Hrs.	0/0
168 Hrs.	0/0

GASKET, BRAKE FLUID RESISTANCE

Enichem

Europrene N 1945 GRN		100
ZnO		5
Stearic acid		1
SRF		80
Paraplex G50		5
Agerite MA		2.5
MBTS		2.5
TMTD		2.5
Sulphur		0.3
Press cure 10 min at 170°C		
T.S.	MPa	15.7
E.B.	%	250
Hardness ShA	points	66
Compression set 70h 70°C	%	10.5
Brittle point	°C	-44
Ageing in Air 70h at 70°C		
Δ T.S.	%	8
Δ E.B.	%	-8
Δ ShA	points	2
Ageing in FIAT brake fluid 70h at 70°C		
Δ Volume	%	33.5
Ageing in isooctane/toluene 65/35 24h at 23°C		
Δ Volume	%	45

70 SHORE A OIL SEAL
Goodyear

Chemigum HR662	108.00	108.00
Hi-Sil LD	40.00	40.00
Carbowax 3350	0.00	0.50
Hercoflex 600	5.00	5.00
Magnesium Oxide	10.00	10.00
Kadox 911C ZnO	5.00	5.00
N-990 Carbon Black	5.00	5.00
Spider Sulfur	0.75	0.75
Unads	2.50	2.50
Santogard PVI	0.40	0.40
Total	**176.65**	**177.15**
Rheometer, 320°F, 1° Arc, 100 CPM, 30 Min. Motor		
Torque, Min. (dN.M)	11.0	9.2
Torque, Max. (dN.M)	60.0	58.9
TS 1 minutes	2.7	2.8
T'90, minutes	7.6	8.7
Rheometer, 340°F, 1° Arc, 100 CPM, 30 Min. Motor		
Torque, Min. (dN.M)	11.4	10.0
Torque, Max. (dN.M)	58.0	57.6
TS 1 minutes	1.9	2.2
T'90, minutes	4.9	5.6
Rheometer, 356°F, 1° Arc, 100 CPM, 20 Min. Motor		
Torque, Min. (dN.M)	11.1	9.7
Torque, Max. (dN.M)	55.2	55.0
TS 1 minutes	1.3	1.4
T'90, minutes	3.1	3.6
ML 1+4 Min. @ 212°F	76	69
Scorch, MS/250°F		
Minimum	30	26
20 minutes reading	30.4	26.4
Specific Gravity	1.233	1.230

**70 SHORE A OIL SEAL
Continued**

Original Properties		
Tensiel, psi	2494	2466
Elongation, %	707	697
10% Modulus, psi	115	116
15% Modulus, psi	130	130
25% Modulus, psi	145	144
50% Modulus, psi	164	165
100% Modulus, psi	196	199
200% Modulus, psi	281	283
Hardness, Shore A	67	67
Hardness, IRDH	68	68
Compression Set (B)		
22 Hrs./302°F(Plied), %	43.7	41.2
22 Hrs./302°F, %	30.0	32.4
46 Hrs./302°F, %	47.7	48.0
70 Hrs./302°F, %	61.2	64.6
Circ. Air Oven Aging - 70 Hrs. @ 302°F		
Tensile, psi	2188	2125
% Change	-12	-14
Elongation, %	748	725
% Change	+6	+4
Shore A Hardness	76	77
Point Change	+9	+10
Fluid Aging - 70 Hrs. @ 302°F, ASTM Oil No. 1		
Tensile, psi	2234	2234
% Change	-10	-9
Elongation, %	711	706
% Change	+1	+1
Shore A Hardness	76	77
Point Change	+9	+10
Volume Swell, %	-2.7	-2.9

70 SHORE A OIL SEAL
Continued

Fluid Aging - 70 Hrs. @ 302°F, ASTM Oil No. 3		
Tensile, psi	1991	2121
% Change	-20	-14
Elongation, %	797	770
% Change	+13	+10
Shore A Hardness	62	62
Point Change	-5	-5
Volume Swell, %	+12.1	+12.6
Fluid Aging - 70 Hrs. @ 302°F, ASTM Reference Fluid IRM903		
Tensile, psi	2181	2332
% Change	-13	-5
Elongation, %	783	750
% Change	+11	+8
Shore A Hardness	62	63
Point Change	-5	-4
Volume Swell, %	+10.1	+9.8
Fluid Aging 96 Hrs. @ 275°F, ASTM Oil No. 1 + 72 Hrs. @ 275°F in Hot Air, Properties After 5 Cycles		
Tensile, psi	1340	1277
% Change	-46	-48
Elongation, %	94	78
% Change	-87	-89
Shore A Hardness	87	88
Point Change	+20	+21
Volume Swell, %	-8.2	-8.0
Bent Loop - 5 Hrs.		
-31°F	Pass	Pass

INTANK ELECTRIC FUEL PUMP ISOLATOR FORMULATION
Goodyear

Chemigum HR665	100.0
Mistron Vapor Talc	60.00
Hi-Sil EP	30.00
Hi-Sil 233	15.00
Ucarsil DSC-18	0.90
Polyethylene AC-617	1.00
Dioctyl Phthalate	45.00
Hercoflex 600	35.00
GPF Black	10.00
Stearic Acid	1.00
Scorchguard "O"	10.00
Protox 169 Zinc Oxide	5.00
Pennac TM	2.00
Durax	1.20
Sulfur	0.30
Sulfasan R	1.20
Santogard PVC	0.40
Total	**318.00**
Specific Gravity	1.295
Original Properties, 20' @ 166°C	
Tensile, psi	1029
Elongation, %	715
300% Modulus, psi	333
Hardness, Shore A	40
ASTM Reference Fuel C, 70 Hrs. @ R.T.	
Tensile, psi	623
Elongation, %	570
Hardness, Shore A	40
Volume Swell, %	+3.7

WATER PUMP SEAL COMPOUND FOR 138°C

Goodyear

Chemigum HR662	100.00
Hi-Sil 233	40.00
Zinc Oxide	3.00
Stearic Acid	1.00
Silane A-189	0.40
TE-80	1.00
Hercoflex 600	7.00
Hallco 3425	8.00
Sulfur	0.30
Methyl Tuads	2.00
Morfax	1.00
Total	**163.70**
Specific Gravity	1.152
Original Properties, 10’ @ 163°C	
Tensile, psi	2247
Elongation, %	740
300% Modulus, psi	450
Hardness, Shore A	59
Compression Set (B), %	
70 Hrs. @ 121°C	29.2
Circ. Air Oven Aging - 70 Hrs./135°C	
Tensile, psi	2624
Elongation, %	680
Hardness, Shore A	72
ASTM No. 3 Oil, 70 Hrs. @ 121°C	
Tensile, psi	2204
Elongation, %	680
Hardness, Shore A	60
Volume Swell, %	+3.4
Ethylene Glycol, 70 Hrs. @ 121°C	
Tensile, psi	2523
Elongation, %	690
Hardness, Shore A	59
Volume Swell, %	-3.8

WATER PUMP SEAL COMPOUND FOR 138°C
Continued

Distilled Water, 500 Hrs. @ 100°C	
Tensile, psi	2668
Elongation, %	690
Hardness, Shore A	60
Volume Swell, %	-3.3
50/50 Ethylene Glycol/Water, 1% Soluble C Oil, 500 Hrs.@ 138°C	
Tensile, psi	2247
Elongation, %	810
Hardness, Shore A	60
Volume Swell, %	+4.2

LOW TEMPERATURE CAPABILITY FOR TRUCK HUB SEALS

Zeon

Zetpol 2010L	100.0
N-774	32.0
Teflon MP-1500	7.5
PlastHall TOTM	10.0
Kadox 911C	3.0
Naugard 445	1.5
Vanox ZMTI	1.0
Armoslip CP	1.5
SR-206	6.0
HVA-2	2.0
Vul-Cup 40KE	8.0
Total	**172.5**
Processing Properties	
Mooney Viscosity	
(1+4) @ 100°C(212°F)	38.7
Mooney Scorch, MS (1 + 30) @ 125°C(257°F)	
Viscosity, min.	19.2
t5, min.	15.3
t35, min.	>30
ODR, Microdie, 100 CPM, 3° Arc @ 170°C(338°F)	
MI, dN-m	6.9
MI, lbf.in.	7.8
Mh, dN-m	74.8
Mh, lbf.in.	84.5
ts2, min.	1.4
t90, min.	16.8
Vulcanizate Properties	
Originals, Cured @ 170°C(338°F), 25 min.	
Hardness, Shore A, pts.	64
Modulus @ 100%, MPa (psi)	3.1(451)
Modulus @ 200%, MPa (psi)	9.1(1318)
Modulus @ 300%, MPa (psi)	16.2(2342)
Tensile, MPa (psi)	19.8(2867)
Elongation, %	350
Tear, Die C, W/G, kN/m	34.3
23°C, pli	196

LOW TEMPERATURE CAPABILITY FOR TRUCK HUB SEALS Continued

Compression Set, Method B	
22 Hr. @ 100°C(212°F), %	6.8
22 Hr. @ 125°C(257°F), %	7.9
22 Hr. @ 150°C(302°F), %	9.0
SPECIFIC GRAVITY	1.14
LOW TEMPERATURE BRITTLENESS (D 2137), °C	<-70
Low Temperature: Gehman (D 1053)	
T2, °C	-13.1
T5, °C	-22.9
T10, °C	-25.9
T100, °C	-31.5
Freeze Point, °C	-31
Aged Properties	
Aged in Air Oven, 70 Hr. @ 100°C(212°F)	
Hardness, A, pts.	66
Hardness, change, pts	2
Tensile, psi	3318
Tensile, change, %	16
Elongation, %	373
Elongation, change, %	7
Aged in ASTM #1 Oil, 70 Hr. @ 100°C(212°F)	
Hardness, A, pts.	65
Hardness, change, pts	1
Tensile, psi	3385
Tensile, change, %	18
Elongation, %	372
Elongation, change, %	6
Volume, %	-6.9
Aged in ASTM #3 Oil, 70 Hr. @ 100°C(212°F)	
Hardness, A, pts.	59
Hardness, change, pts	-5
Tensile, psi	2931
Tensile, change, %	2
Elongation, %	360
Elongation, change, %	3
Volume, %	10.3

SHOCK ABSORBER SEAL

Zeon

Zetpol 3110	100.0
N-774(SRF)	60.0
Hi-Sil 532 EP	30.0
MP 1500	5.0
Armoslip CP	2.0
PlastHall 226	5.0
Koresin P	3.0
Kadox 911C	5.0
Vanox ZMTI	1.0
Naugard 445	1.5
Silane A172	1.0
SR 350	15.0
Vul-Cup 40KE	7.5
Total	**236.0**
Processing Properties	
Mooney Viscosity	
(1+4) @ 100°C(212°F)	78.3
Mooney Scorch, MS (1+30) @ 125°C(257°F)	
Viscosity, min.	53.1
t5, min.	5.0
t35, min.	5.8
ODR, Microdie, 100 CPM, 3° Arc @ 170°C(338°F)	
MI, dN-m	13.5
MI, lbf.in.	15.3
Mh, dN-m	93.2
Mh, lbf.in.	105.3
ts2, min.	0.9
t90, min.	13.4
Vulcanizate Properties	
Originals, Cured @ 170°C(338°F), 16 min.	
Hardness, Shore A, pts	82.0
Modulus @ 100%, MPa (psi)	11.1(1610)
Tensile, MPa (psi)	18(2605)
Elongation, %	182

SHOCK ABSORBER SEAL
Continued

Tear, Die C, W/G, kN/m	31.5
23°C, pli	180
Compression Set, Method B	
70 Hr. @ 150°C(302°F), %	24.4
Aged Properties	
Aged in Air Oven, 70 Hr. @ 150°C(302°F)	
Hardness, A, pts	93
Hardness, change, pts.	11
Tensile, psi	2943
Tensile, change, %	13
Elongation, %	137
Elongation, change, %	-25

OIL & LOW TEMPERATURE RESISTANT GASKET
Enichem

Europrene N 2845		100
ZnO		5
Stearic acid		1
N 330 HAF		70
Vulkanol 85		10
Vulkanox HS		1.5
Vulkanox MB		1.5
Sulfasan R		1.5
TMTD		2
CBS		1.5
Sulphur		0.2
Press cure 10 min at 160°C		
T.S.	MPa	24.1
E.B	%	280
Hardness ShA	points	77
Brittle point	°C	-35
Hardness ShA -40°C	points	99
Compression set 70h 100°C	%	12
Ageing in Air 70h 100°C		
Δ T.S.	%	0
Δ E.B.	%	-15
Δ ShA	points	6
Ageing in ASTM #1 oil 70h 100°C		
Δ T.S.	%	0
Δ E.B.	%	-9
Δ ShA	points	3
Ageing in Water 70h 100°C		
Δ ShA	points	0
Δ Volume	%	3
Ageing in ASTM #3 oil 70h 100°C		
Δ T.S.	%	-6
Δ E.B.	%	-11
Δ ShA	points	-1
Δ Volume	%	8

OIL & LOW TEMPERATURE RESISTANT GASKET
Continued

Ageing in Shell Alvania R2 70h 100°C		
Δ T.S.	%	-17
Δ E.B.	%	-23
Δ ShA	points	-2
Δ Volume	%	6
Ageing in Methanol 70h 100°C		
Δ T.S.	%	-40
Δ E.B.	%	-63
Δ ShA	points	-13
Δ Volume	%	13

GASKET, LOW TEMPERATURE AND GREASE RESISTANT

Enichem

Europrene N OZO 7028		100
ZnO		5
Stearic acid		1
N 550 FEF		40
N 990 MT		30
Vulkanol OT		30
Vulkanox 4010 NA		2
Riowax 721		3
Vulkanox HS		1.5
Vulkanox MB2		1.5
CBS		2
TMTD		2
Sulphur		0.3
Press cure 10 min at 170°C		
T.S.	MPa	112.0
E.B.	%	450
Hardness ShA	points	71
Tear resistance	N/mm	49
Ageing in Ozone 48h at 27°C, 20%, 200 pphm		Pass
Brittle points	°C	-40
Compression set 48h 70°C	%	28
Ageing in Air 48h at 70°C		
Δ T.S.	%	0
Δ E.B.	%	-1
Δ ShA	points	0
Ageing in Molikote grease 48h at 70°C		
Δ T.S.	%	1
Δ E.B.	%	-8
Δ ShA	points	1
Δ Volume	%	-2
Ageing in Water 10gg at 80°C		
Δ T.S.	%	1
Δ E.B.	%	-14
Δ ShA	points	-5
Δ Volume	%	7

CORK GASKET
Enichem

Europrene N 3345		100
ZnO		5
Stearic acid		1
Regal 300		35
Thiokol TP 90B		15
Resin 422R		6
Cotton fiber		15
Cork		100
Caloxol DOP		7
CBS		2
TMTD		2.5
Sulphur		0.75
Press cure 10 min at 160°C		
T.S.	MPa	2.6
Hardness ShA	points	65
Tear resistance	N/mm	19
Bending (-40°C)		Pass

LOW TEMPERATURE GASKET

Enichem

		1	2
Europrene N 1945		100	-
Europrene N 1945 GRN		-	100
ZnO		5	5
Stearic acid		1	1
N 330 HAF		50	50
Anox HB		2	2
Vulkanox MB2		2	2
Vulkanol 85		3	3
MBTS		2.5	2.5
TMTD		2.5	2.5
Sulphur		0.5	0.5
Mooney Compound (1+4) 100°C		57	56
Press cure at 160° for:		5’	4’
M100	MPa	3.0	3.0
M300	MPa	14.8	16.7
T.S.	MPa	15.5	17.9
E.B.	%	320	320
Hardness ShA	points	64	67
Compression set 70h 100°C	%	35	31
Brittle point	°C	-61	-64
Ageing in Air 70h 100°C			
Δ M100	MPa	33	53
Δ T.S.	MPa	-5	-2
Δ E.B.	%	-30	-28
Δ ShA	points	7	7
Δ Volume	%	-2	-2
Brittle point	°C	-64	-63
Ageing in ASTM #3 oil 70h 100°C			
Δ M100	MPa	43	30
Δ M300	MPa	-	-
Δ T.S.	MPa	-29	-43
Δ E.B.	%	-41	-41
Δ ShA	points	-12	-11
Δ Volume	%	45	37
Brittle point	°C	<-65	<-65

HEAT EXCHANGER GASKET
Enichem

Europrene N 3330		100
ZnO		2
Stearic acid		0.5
Lithene PH (liquid polybutadiene)		2
Black N 550		65
Vulkanox 4010 NA		2
TMTD		0.8
TMTM		2.8
TETD		0.8
Sulfasan R		2
Money Compound (1+4) 100°C		58
Rheovulkameter (80°C, 90°C, 170°C,50”,60 bar)*		
Volume	mm^3	1600
Max speed	mm^3/sec	41.8
Scorch at 121°C		
MV		25
T5	min	26
T35	min	59
Rheometer 170°C,24’, arc ±1°		
ML	lb*inch	4.8
MH	lb*inch	52.9
TS1	min	2.3
T50	min	5.8
T90	min	7.5
Press cure 5 min at 170°C + 6h 140°C post-cure in oven		
M100	MPa	8
T.S.	MPa	19.4
E.B.	%	235
Hardness ShA	points	79
Compression set 22h 100°C	%	7
Ageing in Steam 2 months 110°C		
Δ T.S.	%	-45
Δ E.B.	%	-70
Δ ShA	points	6

* piston, die, mould, injection time, injection pressure

FILTER GASKET
Enichem

		1	2
Europrene N 3345		100	100
ZnO		5	5
Stearic acid		1	1
Corax N 550		30	30
Corax N 772		30	50
Black MT		10	-
Anox HB		1	1
Vulkanox MB2		1	1
Irganox 1425		2	2
Struktol WB 300		10	10
TMTD		3	3
MBTS		1	1
Sulfasan R		3	3
Sulphur		0.25	0.25
Mooney Compound (1+4) 100°C		52	63
Scorch at 121°C			
MV		36	43
T5	min	9.2	8.5
T35	min	14.2	13.4
Rheometer 180°C, 24’, arc ±1°			
ML	lb*inch	3.7	4.4
MH	lb*inch	53.4	56.1
TS1	min	1.0	1.0
T50	min	1.7	1.7
T90	min	2.5	2.4
Press cure 3 min at 180°C			
M100	MPa	6.7	8.8
T.S.	MPa	16.1	17.2
E.B.	%	245	200
Hardness Shore A	points	74	78
Tear resistance	N/mm	37	41
Compression set 22h, 120°C	%	15.8	15.5
Brittle point	°C	-28	-27
TR 10	°C	-25	-25

FILTER GASKET
Continued

		1	2
Ageing in Air 166h 120°C			
Δ T.S.	%	12	4
Δ E.B.	%	-47	-58
Δ ShA	points	11	11
Δ Weight	%	-4	-4
Ageing in ASTM #2 oil 70h 120°C			
Δ T.S.	%	-20	-24
Δ E.B.	%	-51	-52
Δ ShA	points	4	3
Δ Weight	%	0.5	0.5
Δ Volume	%	1	1
Ageing in 15W40 oil 70h 125°C			
Δ T.S.	%	-25	-18
Δ E.B.	%	-51	-47
Δ ShA	points	2	2
Δ Weight	%	-3	-2
Δ Volume	%	-2	-2
Ageing in ASTM #1 oil 70h 125°C			
Δ T.S.	%	1	1
Δ E.B.	%	-33	-38
Δ ShA	points	4	5
Δ Weight	%	-4	-4
Δ Volume	%	-4	-5
Ageing in ASTM #3 oil 70h 125°C			
Δ T.S.	%	-4	1
Δ E.B.	%	-31	-22
Δ ShA	points	-3	-3
Δ Weight	%	5	5
Δ Volume	%	7	7

GASKETS
Enichem

		1	2	3	4
Europrene N3345		95	95	90	90
Europrene 1502		5	5	10	10
ZnO		5	5	5	5
Stearic acid		1	1	1	1
N 762 SRF		20	60	75	100
N 550 FEF		20	-	-	-
DOP		15	10	5	-
Anox HB		2	2	2	2
Flectol H		0.5	0.5	0.5	0.5
MBTS		2	2	2	2
TMTD		2.5	2.5	2.5	2.5
Sulphur		0.3	0.3	0.3	0.3
Coumarone resin		-	-	-	5
Press cure 10 min at 160°C					
T.S.	MPa	12.3	15.4	14.6	15.9
E.B.	%	570	540	370	280
Hardness ShA	points	51	60	69	78
Tear resistance	N/mm	23	37	39	44
Compression set 70h 100°C	%	25	22	21	19
Ageing in Air 70h 100°C					
Δ T.S.	%	14	6	18	17
Δ E.B.	%	-25	-26	-14	-14
Δ ShA	points	6	6	6	7
Ageing in ASTM #3 oil 70h 100°C					
Δ T.S.	%	9	0	11	4
Δ E.B.	%	-25	-22	-5	-14
Δ ShA	points	6	3	3	2
Δ Volume	%	1.3	-0.7	1.2	2.2
Ageing in ASTM #1 oil 70h 100°C					
Δ T.S.	%	9	-12	-2	3
Δ E.B.	%	-12	-22	-14	-14
Δ ShA	points	1	-1	-3	-6
Δ Volume	%	4.5	6.4	9.5	10

GASKETS
Enichem

		1	2	3	4
Europrene N 2845 GRN		100	100	100	100
ZnO		5	4	4	5
Stearic acid		1	1	1	1
N 550 FEF		50	50	50	85
N 772 SRF		50	50	50	-
Riowax 721		1	1	1	1
Vulkanox HS		1.5	-	-	-
Vulkanox MB2		1.5	1.5	1.5	
Vulkanol OT		12	-	-	-
Polyplastol 15		2	2	2	-
Mesamoll		-	14	14	14
Vulkanox 4010 NA		-	-	-	2
TMTD		2.5	3	2	1
DTDM		3	3	3	3
MBTS		1	-	-	-
TMTM		-	-	-	3
TETD		-	-	-	1
CBS		-	2.6	2	-
Mooney Compound (1+4) 100°C		59	59	66	61
Scorch at 121C					
MV		42.5	39.6	44.3	40.8
T5	min	10.2	12.8	13.4	17.8
T35	min	20.5	22.4	23.8	36.8
Rheometer 180°C, 24' arc + 1					
ML	lb*inch	4.2	3.7	4.2	4.4
MH	lb*inch	45.2	48.7	45.4	45.4
TS1	min	1.1	1.2	1.2	1.7
T50	min	1.9	1.9	1.9	3.5
T90	min	2.5	2.6	2.5	4.7
Press cure 4 min at 180°C					
M100	MPa	9.1	8.4	8.1	7.2
T.S.	MPa	16.8	16.1	16.8	18.1
E.B.	%	196	189	228	252
Hardness ShA	points	80	80	80	77
Elasticity	%	27	26	26	29
Compression set 70h 100°C	%	6	7	11	6

**GASKETS
Continued**

		1	2	3	4
Ageing in Air 100h 100°C					
Δ T.S.	%	9	8	5	3
Δ E.B.	%	-26	-23	-27	-23
Δ ShA	points	6	6	5	6
Δ Weight	%	-2.8	-2	-2	-2
Ageing in Water 24h 50°C					
Δ T.S.	%	-2	0	-4	-4
Δ E.B.	%	3	2	5	7
Δ ShA	points	-1	-1	-2	-1
Δ Weight	%	1	1	1	1
Δ Volume	%	1	1	1	1
Ageing Water Vapor 48h at 100°C					
Δ T.S.	%	2	7	-2	-4
Δ E.B.	%	-22	-19	-27	-25
Δ ShA	points	2	1	1	2
Δ Weight	%	0	0	1	0
Δ Volume	%	0	1	1	1
Ageing in ASTM #1 oil 100h at 70°C					
Δ T.S.	%	-1	5	-1	-1
Δ E.B.	%	-12	-7	-17	-11
Δ ShA	points	5	5	4	4
Δ Weight	%	-5	-5	-5	-6
Δ Volume	%	-6	-6	-6	-7
Ageing in ASTM #2 oil 100h at 70°C					
Δ T.S.	%	5	9	4	3
Δ E.B.	%	-3	1	-7	-7
Δ ShA	points	2	2	1	2
Δ Weight	%	-2	-3	-2	-2
Δ Volume	%	-3	-3	-3	-3
Ageing in isooctane/toluene 90/1024h at 23°C					
Δ T.S.	%	-7	-6	-16	-13
Δ E.B.	%	-8	-10	-21	-20
Δ ShA	points	-3	-3	-4	-4
Δ Weight	%	3	3	3	4
Δ Volume	%	6	6	6	7

GASKETS
Continued

		1	**2**	**3**	**4**
Ageing in Autol Top 2000 Grease 100h at 50°C					
Δ T.S.	%	-2	-1	-4	-3
Δ E.B.	%	-8	-5	-15	-14
Δ ShA	points	1	1	1	1
Δ Weight	%	-2	-2	-2	-2
Δ Volume	%	-3	-2	-2	-2
Ageing in Rhenolit HLT2 Grease 100h at 50°C					
Δ T.S.	%	-2	3	-5	-2
Δ E.B.	%	2	-2	-11	-8
Δ ShA	points	1	0	-1	0
Δ Weight	%	-2	-1	-1	-1
Δ Volume	%	-2	-1	-1	0

TYPICAL 60 DUROMETER GASKET FORMULATION

Zeon

Nipol AR72HF	100.0
N550	65.0
Stearic Acid	1.0
TE80	2.0
Naugard 445	2.0
HyTemp ZC50	5.0
Thiate H	0.3
Total	**175.3**
Processing Properties	
Mooney Viscometer: Large Rotor, 100°C	
Viscosity Minimum	58
Mooney Viscosity: Large Rotor, 125°C	
Viscosity Minimum	47
T5, minutes	12.3
Rheometer, Microdie, 100 CPM 3° Arc, 190°C	
ML, lbf*in	12.1
ML. N*m	1.4
MH, lbf*in.	56.3
MH, N*m	6.2
Ts2, minutes	1.6
T'90, minutes	7.7
Vulcanized Properties	
Originals: Cure Time 4 minutes @ 190°C	
Stress 100%, psi (MPa)	675(4.7)
Tensile, psi (MPa)	1685(11.6)
Elongation, %	270
Hardness, A points	60
Originals: Cure Time 4 minutes @ 190°C Post Cure Time 4 Hours @ 177°C	
Stress 100%, psi (MPa)	865(6.0)
Tensile, psi (MPa)	1890(13.0)
Elongation, %	275
Hardness, A points	63

TYPICAL 60 DUROMETER GASKET FORMULATION Continued

Compression Set, Method B, Cure Time 4 minutes @ 190°C Post Cure 4 Hours @ 177°C	
Buttons 70 Hrs. @ 150°C % Set	
168	20
1008	60
CSR % Force Retained 1008 Hrs. @ 150°C	
Air Aged	32
Motor Oil	33.3
Aged Properties	
Aging: Environment Tempered Air Oven 70 Hrs. @ 150°C	
Tensile, psi (MPa)	1780(12.3)
Tensile Change, %	-6
Elongation, %	250
Elongation Change, %	-9
Hardness A, points	65
Hardness Change, points	0
Aging: Environment Tempered ASTM #1 Oil 70 Hrs. @ 150°C	
Tensile, psi (MPa)	1875(12.9)
Tensile Change, %	-1
Elongation, %	245
Elongation Change, %	-11
Hardness A, points	71
Hardness Change, points	6
Volume Change, %	-1
Aging: Environment Tempered IRM 903 70 Hrs. @ 150°C	
Tensile, psi (MPa)	1720(11.9)
Tensile Change, %	-9
Elongation, %	265
Elongation Change, %	-4
Hardness A, points	51
Hardness Change, points	-14
Volume Change, %	19

SHAFT SEAL
Enichem

Europrene N 3360		100
ZnO		5
Stearic acid		1
N 330		40
DOP		5
Mistron Vapor		25
Graphite		10
Coumarone resin		2
Vulkanox MB2		1.5
Vulkanox HS		0.5
CBS		1.5
TMTD		2.5
Sulphur		0.4
Press cure 10 min at 170°C		
T.S.	MPa	23.2
E.B.	%	535
Hardness ShA	points	72

SHAFT SEAL
Injection molded
Enichem

Europrene N 3330 GRN		100
ZnO		5
Stearic acid		1
N 330		40
DOP		5
Mistron Vapor		25
Graphite		10
Coumarone resin		2
Vulkanox MB2		1.5
Vulkanox HS		0.5
CBS		1.5
TMTD		2.5
Sulphur		0.4
Press cure 10 min at 170°C		
T.S.	MPa	20.8
E.B.	%	450
Hardness ShA	points	70
Tear resistance	N/mm	42
Compression set 70h, 100°C	%	28
Ageing in ASTM #3 oil (70h, 100°C)		
Δ T.S	%	-3
Δ E.B.	%	11
Δ ShA	points	-1
Δ Volume	%	5
Ageing in ASTM #1 oil (70h, 100°C)		
Δ T.S.	%	6
Δ E.B.	%	-2
Δ ShA	points	2
Δ Volume	%	0
Ageing in Fuel B (70h, 100°C)		
Δ T.S.	%	-54
Δ E.B.	%	-29
Δ ShA	points	-14
Δ Volume	%	26

PRESSURE COOKER SEAL
Enichem

Europrene N 3345 GRN		100
ZnO		5
Stearic acid		1
Kaolin		60
Ultrasil VN3		15
SI 69		0.5
Titanium dioxide		4
Mesamoll		10
DEG		1
TMTD		2
Sulphur		0.4
Mooney Compound (1+4) 100°C		40
Scorch at 121°C		
MV	lb*inch	25
T5	min	16.1
T35	min	23.7
Rheometer 160°C, 24’, arc ± 1°		
ML	lb*inch	5.2
MH	lb*inch	32.8
TS1	min	2.6
T50	min	4.6
T90	min	9.5
Press cure 7 min at 160°C		
M100	MPa	2.3
M300	MPa	4.1
T.S.	MPa	11.8
E.B.	%	800
Hardness ShA	points	60
Compression set 70h 100°C	%	57
Ageing in Water/Olive Oil/Vinegar/Salt: 90/4/4/2 (wt.) 70h at 100°C		
Δ T.S.	%	-8
Δ E.B.	%	-24
Δ ShA	points	2
Δ Weight	%	2
Δ Volume	%	3
Δ Thickness	%	3

PRESSURE COOKER SEAL
Enichem

Europrene N 2860		100
ZnO		3
Stearic acid		1
Silteg AS7		25
Calcium carbonate		120
DOA		5
Vulkanox BKF		2
Vaselin oil		2
Titanium dioxide		4
Rhenocure S/G		1.5
Perkacid TBzTD		1
Sulphur		0.5
Mooney Compound (1+4) 100°C		98
Scorch at 121°C		
MV	lb*inch	75
T5	min	8.2
T35	min	9.6
Rheometer 160°C, 24’, arc ± 1°		
ML	lb*inch	10.4
MH	lb*inch	31.4
TS1	min	0.8
T50	min	1.0
T90	min	3.0
Press cure 7 min at 160°C		
M100	MPa	1.0
M300	MPa	2.0
T.S.	MPa	8.2
E.B.	%	840
Hardness ShA	points	57
Compression set 70h 100°C	%	71
Ageing in Air 168h at 121°C		
Δ T.S.	%	-20
Δ E.B.	%	-62
Δ ShA	points	19
Δ Weight	%	-4

PRESSURE COOKER SEAL
Continued

Ageing in Water 168h at 100°C		
Δ T.S.	%	19
Δ E.B.	%	-10
Δ ShA	points	-4
Δ Weight	%	18
Δ Volume	%	28
Ageing in Olive oil 70h at 100°C		
Δ T.S.		-11
Δ E.B.		-8
Δ ShA		-3
Δ Weight		2
Δ Volume		4
Ageing in Water/Acetic acid 75/25 70h at 100°C		
Δ T.S.		-57
Δ E.B.		-46
Δ ShA		-37
Δ Weight		58
Δ Volume		24

TRANSFER MOLDED SEALS
DSM

	1	2	3
Nysyn 33-55R	100.0	---	---
Nysyn 33-5HM	---	100.0	---
Nysyn 30-5	---	---	100.0
Sulfur	0.5	0.5	0.5
Zinc Oxide	5.0	5.0	5.0
Stearic Acid	1.0	1.0	1.0
Paraffin Wax	1.0	1.0	1.0
Struktol TR-131	1.0	1.0	1.0
N-550 Black	20.0	20.0	20.0
N-660 Black	30.0	30.0	30.0
AGERITE RESIN D	1.0	1.0	1.0
Ethyl Thiurad	2.0	2.0	2.0
Santocure MOR	1.75	1.75	1.75
Santocure PVI	0.5	0.5	0.5
Total	163.8	163.8	163.8
Physical Properties			
Compound Viscosity,			
ML (1+4) 100°C	65	62	58
Mooney Scorch @ 132°C			
Minutes to 5 Pt. Rise	13.8	13.3	15.7
Reading	20	19	19
Press Cure @ 160°C, 20 min. cure			
Tensile, MPa	19.2	18.27	17.58
Elongation, %	510	530	460
100% Modulus, MPa	1.55	1.2	0.90
200% Modulus, MPa	5.17	4.83	4.48
300% Modulus, MPa	10.85	9.48	10
Hardness, Shore A	67	66	66
Compression Set, %			
70 Hrs. @ 125°C, 30 min. cure	23.3	26.4	23.6
After Air Oven Aging 70 Hrs. @ 125°C, 20 min. cure			
Tensile, % Change	-6	+3	+12
Elongation, % Change	-45	-42	-30
Hardness, Pts. Change	+7	+8	+6

TRANSFER MOLDED SEALS
Continued

After immersion in ASTM Oil #3 70 Hrs. @ 100°C, 20 min. cure			
Tensile, % Change	-1	-2	-9
Elongation, % Change	-16	-21	-24
Hardness, Pts. Change	-8	-9	-8
Volume Change, %	+14.4	+15.6	+19.9
After immersion in ASTM Fuel B 70 Hrs. @ 23°C, 20 min. cure			
Tensile, % Change	-56	-54	-61
Elongation, % Change	-51	-49	-54
Hardness, Pts. Change	-15	-17	-13
Volume Change, %	+33.8	+34.8	+38.1

O-RING
Peroxide curing
Enichem

Europrene N 3330 GRN		100
ZnO		3
N 550 FEF		30
N 762 SRF		45
Vulkanox MB2		2
Anox HB		2
DOP		9
Dicup 40		4.9
Press cure 10 min at 170°C		
T.S.	MPa	18.5
E.B.	%	270
Hardness ShA	points	70
Compression set 70h 100°C	%	11
Bending test (-30°C)		Pass
Ageing in ASTM #3 oil 70h 125°C		
Δ T.S.	%	-4
Δ E.B.	%	1
Δ ShA	points	-11
Δ Volume	%	7
Ageing in ASTM #2 oil 14 days 125°C		
Δ T.S.	%	8
Δ E.B.	%	-13
Δ ShA	points	2.5
Δ Volume	%	1
Ageing in ASTM #5 oil 70h 125°C		
Δ T.S.	%	4
Δ E.B.	%	-2
Δ ShA	points	-24
Δ Volume	%	-5.5
Ageing in Fuel A 70h 23°C		
Δ T.S.	%	-2
Δ E.B.	%	-5
Δ ShA	points	-7
Δ Volume	%	0.5

O-RING
Peroxide curing
Continued

Ageing in Fuel B 70h 23°C		
Δ T.S.	%	-15
Δ E.B.	%	-45
Δ ShA	points	-35
Δ Volume	%	26
Ageing in Water 70h 100°C		
Δ T.S.	%	0
Δ E.B.	%	1
Δ ShA	points	-8
Δ Volume	%	4
Ageing in Ethyleneglycol/Water 50/50 70h 100°C		
Δ T.S.	%	-1
Δ E.B.	%	2
Δ ShA	points	-11
Δ Volume	%	3.5

MOLDED GOODS COMPOUNDS
To Meet S.A.E. J200 M6BG910A14B14B34EO14EO34
Zeon

	1	2	3
Nipol 1072EP	100.00	100.00	100.00
N-550 Black	60.00	60.00	50.00
A(RZNO)D-60P	----	----	10.00
WR(ZnO-85)	10.00	10.00	----
Agerite Resin D	3.00	3.00	3.00
Stearic Acid	2.00	2.00	2.00
Plasthall 7050	10.00	----	----
Saret 500 DLC	27.00	10.00	27.00
Dicup 40C	3.50	3.50	3.50
Total	**215.50**	**188.50**	**195.50**
Mixing Properties			
Drop Temp., ° C	120	120	120
Mix Time, minutes	3.1	2.3	2.1
Processing Properties			
Mooney Viscosity			
ML (1+4) @ 100°C	36.0	46.4	43.2
Mooney Scorch: ML(1+30) @ 125°C			
Viscosity, min.	22.9	28.9	26.2
t5, minutes	10.3	9.2	14.3
t35, minutes	16.1	14.1	17.6
ODR: Microdie, 100 CPM, 3° Arc @ 170°C			
ML, dN-m	5.1	7.9	6.6
ML, (lbf-in)	5.8	8.9	7.5
MH, dN-m	119.9	141.0	123.6
MH, (lbf-in)	135.5	159.3	139.6
ts2, minutes	1.2	1.1	1.3
t'90, minutes	8.5	9.5	9.9

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M6BG910A14B14B34EO14EO34
Continued

Vulcanized Properties			
Originals: Cured @ 170°C			
Hardness (A), pts.	89	92	90
Stress 50%, MPa	9.6	12.7	11.9
Stress 50%, psi	1390	1847	1726
Stress 100%, MPa	16.7	20.5	19.5
Stress 100%, psi	2425	2974	2832
Stress 200%, MPa			
Stress 200%, psi			
Tensile, MPa	18.9	20.6	21.8
Tensile, psi	2736	2985	3160
Elongation, %	124	105	115
Compression Set: Method B			
22 Hrs. @ 100°C, Buttons	20.0	21.1	18.3
22 Hrs. @ 100°C, Discs	20.8	25.0	23.5
Aged Properties			
Aged in: Air Oven, 70 Hrs. @ 100°C			
Hardness (A), pts.	93	93	94
Hardness Change, pts.	4	1	4
Tensile, psi	3022	3528	3754
Tensile Change, %	10	18	16
Elongation, %	100	85	105
Elongation Change, %	-19	-19	-9
Aged in: Air Test Tube, 70 Hrs. @ 100°C			
Hardness (A), pts.	93	94	91
Hardness Change, pts.	4	2	1
Tensile, psi	3260	3726	3698
Tensile Change, %	19	25	17
Elongation, %	109	91	95
Elongation Change, %	-12	-13	-17

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M6BG910A14B14B34EO14EO34
Continued

Aged in: ASTM Fuel A, 70 Hrs. @ 23°C			
Hardness (A), pts.	85	89	88
Hardness Change, pts.	-4	-3	-2
Tensile, psi	2378	3120	3125
Tensile Change, %	-13	5	-1
Elongation, %	104	115	132
Elongation Change, %	-16	10	15
Volume Change, %	1.6	1.7	1.4
Aged in: ASTM Fuel B, 70 Hrs. @ 23°C			
Hardness (A), pts.	74	75	73
Hardness Change, pts.	-15	-17	-17
Tensile, psi	1830	1864	1782
Tensile Change, %	-33	-38	-44
Elongation, %	111	98	102
Elongation Change, %	-10	-7	-11
Volume Change, %	22.9	28.5	29.8
Aged in: ASTM Oil #1, 70 Hrs. @ 100°C			
Hardness (A), pts.	93	93	91
Hardness Change, pts.	4	1	1
Tensile, psi	3490	3660	3778
Tensile Change, %	28	23	20
Elongation, %	85	82	101
Elongation Change, %	-31	-22	-12
Volume Change, %	-5.8	-2.8	-2.8
Aged in: IRM 903 Oil, 70 Hrs. @ 100°C			
Hardness (A), pts.	89	89	89
Hardness Change, pts.	0	-3	-1
Tensile, psi	2945	2748	2959
Tensile Change, %	8	-8	-6
Elongation, %	76	66	82
Elongation Change, %	-39	-37	-29
Volume Change, %	4.1	7.4	8.3

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M6BG910A14B14B34EO14EO34
Continued

Aged in: Distilled H_2O, 70 Hrs. @ 100°C			
Hardness (A), pts.	88	91	86
Hardness Change, pts.	-1	-1	-4
Tensile, psi	2757	3055	2974
Tensile Change, %	1	2	-6
Elongation, %	107	103	122
Elongation Change, %	-14	-2	6
Volume Change, %	0.7	1.5	5.5

MOLDED GOOD FORMULATION
To Meet
S.A.E. J200 M3CH717A25B14B34EO16EO36
S.A.E. J200 M2CH717A24B14B34EO15EO35
Zeon

Nipol DN4050	100.00
Kadox 920C	5.00
Stangard 500	3.00
Spider Sulfur	0.50
Stearic Acid	1.00
N-550 Black	30.00
N-774 Black	30.00
Plastahall 7050	5.00
TMTD	1.00
TETD	1.00
OBTS	1.00
Total	**177.50**
Processing Properties	
Mooney Viscosity	
ML (1+4) @ 100°C	74.4
Mooney Scorch: ML(1+30) @ 125°C	
Viscosity, min.	52.1
t5, minutes	3.4
t35, minutes	5.1
ODR: Microdie, 100 CPM, 3° Arc @ 170°C	
ML, dN-m	12.7
ML, (lbf-in)	14.4
MH, dN-m	89.0
MH, (lbf-in)	100.6
ts2, minutes	0.9
t’90, minutes	3.0
Cure, minutes	7.0

MOLDED GOOD FORMULATION
S.A.E. J200 M3CH717A25B14B34EO16EO36
S.A.E. J200 M2CH717A24B14B34EO15EO35
Continued

Vulcanized Properties	
Originals: Cured @ 170°C	
Hardness (A), pts.	75
Stress, 50%, MPa(psi)	2.5(364)
Stress 100%, MPa(psi)	4.9(704)
Stress 200%, MPa(psi)	11.7(1694)
Tensile, MPa(psi)	20.5(2966)
Elongation, %	410
Compression Set: Method B	
22 Hrs. @ 100°C, Discs	20.4
22 Hrs. @ 100°C, Buttons	14.5
Aged Properties	
Aged in: Air Test Tube, 70 Hrs. @ 125°C	
Hardness, (A), pts.	79
Hardness Change, pts.	4
Tensile, psi	3485
Tensile Change, %	17
Elongation, %	328
Elongation Change, %	-20
Aged in: ASTM #1 Oil, 70 Hrs. @ 150°C	
Hardness, (A), pts.	79
Hardness Change, pts.	4
Tensile, psi	3559
Tensile Change, %	20
Elongation, %	362
Elongation Change, %	-12
Volume Change, %	-5.5
Aged in: IRM 903 Oil, 70 Hrs. @ 150°C	
Hardness, (A), pts.	72
Hardness Change, pts.	-3
Tensile, psi	3202
Tensile Change, %	8
Elongation, %	340
Elongation Change, %	-17
Volume Change, %	3.5

MOLDED GOODS FORMULATION
To Meet
S.A.E. J200 M3CH814A25B14B34EO16EO36
S.A.E. J200 M2CH814A25B14B34EO15EO35
Zeon

Nipol DN4050	100.00
Kadox 920C	5.00
Stangard 500	3.00
Spider Sulfur	0.50
Stearic Acid	1.00
N-550 Black	30.00
N-775 Black	30.00
Cumar P-25	5.00
TMTD	1.00
TETD	1.00
OBTS	1.00
Total	**177.50**
Processing Properties	
Mooney Viscosity	
ML (1+4) @ 100°C	87.6
Mooney Scorch: ML(1+30) @ 125°C	
Viscosity, min.	59.3
t5, minutes	3.8
t35, minutes	5.5
ODR: Microdie, 100 CPM, 3° Arc @ 170°C	
ML, dN-m	14.3
ML, (lbf-in)	16.2
MH, dN-m	90.0
MH, (lbf-in)	101.7
ts2, minutes	1.0
t'90, minutes	3.0
Cure, minutes	7.0

MOLDED GOODS FORMULATION
S.A.E. J200 M3CH814A25B14B34EO16EO36
S.A.E. J200 M2CH814A25B14B34EO15EO35
Continued

Vulcanized Properties	
Originals: Cured @ 170°C	
Hardness (A), pts.	77
Stress, 50%, MPa(psi)	2.5(362)
Stress 100%, MPa(psi)	5.0(721)
Stress 200%, MPa(psi)	12.4(1805)
Tensile, MPa(psi)	21.1(3061)
Elongation, %	414
Compression Set: Method B	
22 Hrs. @ 100°C, Discs	20.5
22 Hrs. @ 100°C, Buttons	13.7
Aged Properties	
Aged in: Air Test Tube, 70 Hrs. @ 125°C	
Hardness, (A), pts.	82
Hardness Change, pts.	5
Tensile, psi	3461
Tensile Change, %	13
Elongation, %	288
Elongation Change, %	-30
Aged in: ASTM #1 Oil, 70 Hrs. @ 150°C	
Hardness, (A), pts.	79
Hardness Change, pts.	2
Tensile, psi	3343
Tensile Change, %	9
Elongation, %	294
Elongation Change, %	-29
Volume Change, %	-4.5
Aged in: IRM 903 Oil, 70 Hrs. @ 150°C	
Hardness, (A), pts.	72
Hardness Change, pts.	-5
Tensile, psi	3340
Tensile Change, %	9
Elongation, %	361
Elongation Change, %	-13
Volume Change, %	4.9

MOLDED GOODS FORMULATON
To Meet
S.A.E. J200 M4CH910 A25B14EF31EO15EO35
S.A.E. J200 M2CH910 A25B14B34EF31EO15EO35
Zeon

Nipol DN4050	100.00	100.00
Kadox 911C	5.00	5.00
Stangard 500	3.00	3.00
Stearic Acid	1.00	1.00
DOP	5.00	----
Plasthall TOTM	----	10.00
N-774 Black	----	85.00
N-550 Black	55.00	----
Saret 500	20.00	28.00
Dicup 40C	3.50	3.50
Total	**192.50**	**235.50**
Mixing Properties		
Drop Temp., °C	122	111
Mix Time, minutes	3.0	4.0
Processing Properties		
Mooney Viscosity		
ML (1+4) @ 100°C	37.6	40.8
Mooney Scorch: ML (1+30) @ 125°C		
Viscosity, min.	21.3	25.2
t5, minutes	>30.0	>30.0
t35, minutes	>30.0	>30.0
ODR: Microdie, 100 CPM, 3° Arc @ 170°C		
ML, dN-m	5.1	4.5
ML, (lbf-in)	5.8	5.1
MH, dN-m	84.8	73.2
MH, (lbf-in)	95.8	82.7
ts2, minutes	1.7	1.6
t'90, minutes	5.6	7.4
Cure, minutes	15.0	15.0

MOLDED GOODS FORMULATON
S.A.E. J200 M4CH910 A25B14EF31EO15EO35
S.A.E. J200 M2CH910 A25B14B34EF31EO15EO35
Continued

Vulcanized Properties		
Originals: Cured @ 170°C		
Hardness (A), pts.	86	92
Stress, 50%, MPa(psi)	4.4(635)	9.6(1394)
Stress 100%, MPa(psi)	8.1(1172)	17.1(2480)
Stress 200%, MPa(psi)	15.4(2226)	
Tensile, MPa(psi)	19.9(2889)	20.9(3031)
Elongation, %	159	148
Compression Set: Method B		
22 Hrs. @ 100°C, Discs	12.1	17.7
22 Hrs. @ 100°C, Buttons	16.0	16.3
Aged Properties		
Aged in: Air Test Tube, 70 Hrs. @ 125°C		
Hardness, (A), pts.	87	94
Hardness Change, pts.	1	2
Tensile, psi	3171	3502
Tensile Change, %	10	16
Elongation, %	120	116
Elongation Change, %	-25	-22
Aged in: ASTM #1, 70 Hrs. @ 125°C		
Hardness, (A), pts.	90	95
Hardness Change, pts.	4	3
Tensile, psi	3388	3480
Tensile Change, %	17	15
Elongation, %	138	107
Elongation Change, %	-13	-28
Volume Change, %	-4.8	-4.6
Aged in: IRM 903 Oil, 70 Hrs. @ 125°C		
Hardness, (A), pts.	84	91
Hardness Change, pts.	-2	-1
Tensile, psi	2871	3251
Tensile Change, %	-1	7
Elongation, %	118	111
Elongation Change, %	-26	-25
Volume Change, %	3.1	2.5

MOLDED GOODS FORMULATON
To Meet
S.A.E. J200 M4CH910 A25B14EF31EO15EO35
S.A.E. J200 M2CH910 A25B14B34EF31EO15EO35
CONTINUED

Aged in: Fuel C, 70 Hrs. @ 23°C		
Hardness, (A), pts.	68	75
Hardness Change, pts.	-18	-17
Tensile, psi	1248	1741
Tensile Change, %	-57	-43
Elongation, %	80	83
Elongation Change, %	-50	-44
Volume Change, %	32.7	31.0

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 BF714B14EO14F19
Zeon

Nipol DN401LL	100.00
N-330 Black	75.00
Kadox 911C	5.00
Agerite Resin D	3.00
Stearic Acid	1.00
DOP	15.00
Spider Sulfur	0.50
TMTD	1.00
TETD	1.00
OBTS	1.00
Total	**202.50**
Mixing Properties	
Drop Temp., °C	130
Mix Time, minutes	2.8
Processing Properties	
Mooney Viscosity	
ML(1+4) @ 100°C	62.8
Mooney Scorch: ML (1+30) @ 125°C	
Viscosity, min.	46.2
t5, minutes	14.5
t35, minutes	22.1
ODR: Microdie, 100 CPM, 3° Arc @ 170°C	
ML, dN-m	11.2
ML, (lbf-in)	12.7
MH, dN-m	66.8
MH, (lbf-in)	75.5
ts2, minutes	1.8
t'90, minutes	4.3
Cure, minutes	10.0

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 BF714B14EO14F19
Continued

Vulcanized Properties	
Originals: Cured @ 170°C	
Hardness (A), pts.	67
Stress, 50%, MPa(psi)	1.8(259)
Stress 100%, MPa(psi)	3.3(472)
Stress 200%, MPa(psi)	8.9(1287)
Tensile, MPa(psi)	19.4(2819)
Elongation, %	383
Low Temperature Brittleness ASTM D2137	
Pass, °C	-56
Compression Set: Method B	
22 Hrs. @ 100°C, Discs	25.2
22 Hrs. @ 100°C, Buttons	13.5
Aged Properties	
Aged in: Air Oven, 70 Hrs. @ 100°C	
Hardness, (A), pts.	76
Hardness Change, pts.	9
Tensile, psi	2906
Tensile Change, %	3
Elongation, %	287
Elongation Change, %	-25
Aged in: ASTM #1 Oil, 70 Hrs. @ 100°C	
Hardness, (A), pts.	74
Hardness Change, pts.	7
Tensile, psi	3047
Tensile Change, %	8
Elongation, %	322
Elongation Change, %	-16
Volume Change, %	-4.8

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 BF714B14EO14F19
Continued

Aged in: IRM 903, 70 Hrs. @ 100°C	
Hardness, (A), pts.	44
Hardness Change, pts.	-23
Tensile, psi	2274
Tensile Change, %	-19
Elongation, %	285
Elongation Change, %	-26
Volume Change, %	35.7

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 BF614B14B34EO14EO34F19
Zeon

Nipol DN401LL	100.00
N-330 Black	75.00
Kadox 911C	5.00
Agerite Resin D	3.00
Stearic Acid	1.00
DOP	25.00
Spider Sulfur	0.50
TMTD	1.00
TETD	1.00
OBTS	1.00
Total	**212.50**
Mixing Properties	
Drop Temp., °C	120
Mix Time, minutes	4.0
Processing Properties	
Mooney Viscosity	
ML(1+4) @ 100°C	42.8
Mooney Scorch: ML (1+30) @ 125°C	
Viscosity, min.	31.7
t5, minutes	17.5
t35, minutes	26.5
ODR: Microdie, 100 CPM, 3° Arc @ 170°C	
ML, dN-m	7.6
ML, (lbf-in)	8.6
MH, dN-m	55.8
MH, (lbf-in)	63.1
ts2, minutes	2.0
t’90, minutes	4.8
Cure, minutes	10.0

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 BF614B14B34EO14EO34F19
Continued

Vulcanized Properties	
Originals: Cured @ 170°C	
Hardness (A), pts.	62
Stress, 50%, MPa(psi)	1.4(197)
Stress 100%, MPa(psi)	2.4(346)
Stress 200%, MPa(psi)	6.5(949)
Tensile, MPa(psi)	19.1(2771)
Elongation, %	449
Low Temperature Brittleness ASTM D 2137	
Pass, °C	-57
Compression Set: Method B	
22 Hrs. @ 100°C, Discs	21.3
22 Hrs. @ 100°C, Buttons	17.2
Aged in: Air Oven, 70 Hrs. @ 100°C	
Hardness, (A), pts.	70
Hardness Change, pts.	8
Tensile, psi	2941
Tensile Change, %	6
Elongation, %	362
Elongation Change, %	-19
Aged in: ASTM #1 Oil, 70 Hrs. @ 100°C	
Hardness, (A), pts.	70
Hardness Change, pts.	8
Tensile, psi	2966
Tensile Change, %	7
Elongation, %	360
Elongation Change, %	-20
Volume Change, %	-9.3
Aged in: IRM 903, 70 Hrs. @ 100°C	
Hardness, (A), pts.	42
Hardness Change, pts.	-20
Tensile, psi	2167
Tensile Change, %	-22
Elongation, %	316
Elongation Change, %	-30
Volume Change, %	31.1

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M6BG814A14B14B34EO34F17
Zeon

Nipol DN3350	100.00
N550 Black	60.00
N774 Black	40.00
Stangard 500	3.00
Kadox 911C	5.00
Stearic Acid	1.00
DOA	18.00
Spider Sulfur	0.40
MBTS	3.00
Methyl Zimate	1.00
Total	**231.40**
Processing Properties	
Mooney Viscosity	
ML (1+4) @ 100°C	80.6
Mooney Scorch: ML (1+30) @ 125°C	
Viscosity, min.	57.1
t5, minutes	5.7
t35, minutes	6.9
ODR: Microdie, 100 CPM, 3° Arc @ 170°C	
ML, dN-m	12.0
ML, (lbf-in)	13.6
MH, dN-m	78.9
MH, (lbf-in)	89.2
ts2, minutes	1.2
t'90, minutes	3.3
Cure, minutes	10.0
Vulcanized Properties	
Originals: Cured @ 170°C	
Hardness (A), pts.	78
Stress 50%, MPa(psi)	2.9(425)
Stress 100%, MPa(psi)	5.9(855)
Stress 200%, MPa(psi)	12.0(1742)
Tensile, MPa(psi)	18.1(2619)
Elongation, %	353

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M6BG814A14B14B34EO34F17
Continued

Tear: Die C, W/G	
23°C, kN/m(pli)	53.8(307)
Compression Set: Method B	
22 Hrs. @ 100°C, discs, % Set	13.7
22 Hrs. @ 100°C, buttons, % Set	18.5
70 Hrs. @ 100°C, discs, % Set	12.8
70 Hrs. @ 100°C, buttons, % Set	22.2
Low Temperature Brittleness, ASTM D2137	
Pass, °C	-44
Low Temperature Torsional Modulus, ASTM D 1053	
T2, °C	-12.7
T5, °C	-26.2
T10, °C	-30.9
T100, °C	-39.8
Freeze Point, °C	-38.0
Aged Properties	
Aged in: Air Oven, 70 Hrs. @ 100°C	
Hardness, (A), pts.	83
Hardness Change, pts.	5
Tensile, psi	2748
Tensile Change, %	5
Elongation, %	284
Elongation Change, %	-20
Aged in: ASTM #1 Oil, 70 Hrs. @ 100°C	
Hardness, (A), pts.	84
Hardness Change, pts.	6
Tensile, psi	2975
Tensile Change, %	14
Elongation, %	295
Elongation Change, %	-16
Volume Change, %	-9.9

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M6BG814A14B14B34EO34F17
Continued

Aged in: IRM 903 Oil, 70 Hrs. @ 100°C	
Hardness, (A), pts.	72
Hardness Change, pts.	-6
Tensile, psi	2864
Tensile Change, %	9
Elongation, %	289
Elongation Change, %	-18
Volume Change, %	0.3
Aged in: Fuel A, 70 Hrs. @ 23°C	
Hardness, (A), pts.	76
Hardness Change, pts.	-2
Tensile, psi	2617
Tensile Change, %	-0
Elongation, %	342
Elongation Change, %	-3
Volume Change, %	-0.5
Aged in: Fuel B, 70 Hrs. @ 23°C	
Hardness, (A), pts.	55
Hardness Change, pts.	-23
Tensile, psi	2111
Tensile Change, %	-19
Elongation, %	280
Elongation Change, %	-21
Volume Change, %	22.5
Aged in: Fuel C, 70 Hrs. @ 23°C	
Hardness, (A), pts.	46
Hardness Change, pts.	-32
Tensile, psi	1768
Tensile Change, %	-32
Elongation, %	216
Elongation Change, %	-39
Volume Change	37.6
Volume Change, %	29.7
After 15 min. 23°C dryout	

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M6BG814A14B14B34EO34F17
Continued

Aged in: Distilled H_20, 70 Hrs. @ 100°C	
Hardness, (A), pts.	72
Hardness Change, pts.	-6
Tensile, psi	2663
Tensile Change, %	2
Elongation, %	291
Elongation Change, %	-18
Volume Change, %	3.7

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M2BG410B14B34EA14EF11EO34F17
Zeon

Nipol DN3380	100.00
N774 Black	30.00
Agerite Resin D	2.00
Kadox 911C	5.00
Stearic Acid	1.00
DOP	20.00
Paraplex G25	10.00
Spider Sulfur	0.50
TMTD	1.00
OBTS	2.00
Total	**171.50**
MIXING PROPERTIES	
Drop Temp., °C	100
Mix Time, minutes	6.0
Processing Properties	
Mooney Viscosity	
ML (1+4) @ 100°C	29.6
Mooney Scorch: ML (1+30) @ 125°C	
Viscosity, min.	19.4
t5, minutes	17.5
t35, minutes	22.5
ODR: Microdie, 100 CPM, 3° Arc @ 170°C	
ML, dN-m	6.0
ML, (lbf-in)	6.8
MH, dN-m	47.0
MH, (lbf-in)	53.1
ts2, minutes	2.1
t'90, minutes	5.8
Cure, minutes	10.0

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M2BG410B14B34EA14EF11EO34F17
Continued

Vulcanized Properties		
Originals: Cured @ 170°C		
		Specification
Hardness (A), pts.	44	35-45
Stress 50%, MPa(psi)	0.7(101)	
Stress 100%, MPa(psi)	1.0(151)	
Stress 200%, MPa(psi)	1.9(280)	
Tensile, MPa(psi)	13.1(1895)	1450
Elongation, %	631	450
Compression Set: Method B		
22 Hrs. @ 100°C, discs, % Set	13.5	25
22 Hrs. @ 100°C, buttons, % Set	6.0	25
Low Temperature Brittleness, ASTM D2137		
Pass, °C	-45	-40
Aged Properties		
Aged in: Air Oven, 70 Hrs. @ 100°C		
Hardness, (A), pts.	44	
Hardness Change, pts.	0	±15
Tensile, psi	1852	
Tensile Change, %	-2	±30
Elongation, %	553	
Elongation Change, %	-12	±50
Aged in: ASTM #1 Oil, 70 Hrs. @ 100°C		
Hardness, (A), pts.	44	
Hardness Change, pts.	0	
Tensile, psi	2522	
Tensile Change, %	33	
Elongation, %	754	
Elongation Change, %	19	
Volume Change, %	-12.1	

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M2BG410B14B34EA14EF11EO34F17
Continued

Aged in: IRM 903 Oil, 70 Hrs. @ 100°C		
Hardness, (A), pts.	36	
Hardness Change, pts.	-8	-10+5
Tensile, psi	1621	
Tensile Change, %	-14	-45
Elongation, %	593	
Elongation Change, %	-6	-45
Volume Change, %	7.6	25
Aged in: Fuel A, 70 Hrs. @ 23°C		
Hardness, (A), pts.	39	
Hardness Change, pts.	-5	±10
Tensile, psi	1595	
Tensile Change, %	-16	-25
Elongation, %	614	
Elongation Change, %	-3	-25
Volume Change, %	3.1	-5 +10
Aged in: Fuel B, 70 Hrs. @ 23°C		
Hardness, (A), pts.	28	
Hardness Change, pts.	-16	
Tensile, psi	491	
Tensile Change, %	-74	
Elongation, %	296	
Elongation Change, %	-53	
Volume Change, %	30.9	
Aged in: Fuel C, 70 Hrs. @ 23°C		
Hardness, (A), pts.	25	
Hardness Change, pts.	-19	
Tensile, psi	306	
Tensile Change, %	-84	
Elongation, %	207	
Elongation Change, %	-67	
Volume Change, %	63.4	

MOLDED GOODS COMPOUND
To Meet S.A.E. J200 M2BG410B14B34EA14EF11EO34F17
Continued

Aged in: Distilled $H_2$0, 70 Hrs. @ 100°C		
Hardness, (A), pts.	42	
Hardness Change, pts.	-2	±10
Tensile, psi	1604	
Tensile Change, %	-15	
Elongation, %	547	
Elongation Change, %	-13	
Volume Change, %	3.2	±15

MOLDED GOODS COMPOUND
To Meet M2BG514B34EA14EF11EO14EO34F17
Zeon

	1	2
Nipol DN3380	100.00	100.00
N774 Black	55.00	50.00
Agerite Resin D	2.00	2.00
Kadox 911C	5.00	5.00
Stearic Acid	1.00	1.00
DOA	15.00	----
DOP	----	15.00
Paraplex G25	10.00	10.00
Spider Sulfur	0.50	0.50
TMTD	1.00	1.00
OBTS	2.00	2.00
Total	**191.50**	**186.50**
Mixing Properties		
Drop Temp., °C	119	120
Mix Time, minutes	4.8	3.8
Processing Properties		
Mooney Viscosity		
ML (1+4) @ 100°C	38.3	40.0
Mooney Scorch: ML (1+30) @ 125°C		
Viscosity, min.	28.3	26.9
t5, minutes	5.9	13.2
t35, minutes	8.2	17.3
ODR: Microdie, 100 CPM, 3° Arc @ 170°C		
ML, dN-m	8.0	8.5
ML, (lbf-in)	9.0	9.6
MH, dN-m	74.5	58.0
MH, (lbf-in)	84.2	65.5
ts2, minutes	1.3	1.8
t90, minutes	4.0	5.1
Cure, minutes	10.0	10.0

MOLDED GOODS COMPOUND
To Meet M2BG514B34EA14EF11EO14EO34F17
Continued

Vulcanized Properties			
Originals: Cured @ 170°C			
Hardness (A), pts.	45-55	53	53
Stress 50%, MPa(psi)		1.1(163)	0.9(136)
Stress 100%, MPa(psi)		1.7(247)	1.5(211)
Stress 200%, MPa(psi)		4.1(600)	3.1(448)
Tensile, MPa(psi)	(2030)	17.3(2503)	18.1(2630)
Elongation, %	350	516	615
Tear: Die C, W/G			
23°C, kN/m(pli)		37.0(211)	
Compression Set: Method B			
22 Hrs. @ 100°C, discs, % Set	25	11.0	12.0
22 Hrs. @ 100°C, buttons, % Set	25	9.7	6.8
Low Temperature Brittleness, ASTM D2137			
Pass, °C	-40	-46	-41
Low Temperature Torsional Modulus, ASTM D1053			
T2, °C		-26.7	
T5, °C		-35.2	
T10, °C		-37.1	
T100, °C		-39.7	
Freeze Point, °C		-40.0	
Aged Properties			
Aged in: Air Oven, 70 Hrs. @ 100°C			
Hardness, (A), pts.		53	53
Hardness Change, pts.	±15	0	0
Tensile, psi		2634	2667
Tensile Change, %	±30	5	1
Elongation, %		481	530
Elongation Change, %	-50	-7	-14

MOLDED GOODS COMPOUND
To Meet M2BG514B34EA14EF11EO14EO34F17
Continued

Aged in: ASTM #1 Oil, 70 Hrs. @ 100°C			
Hardness, (A), pts.		53	55
Hardness Change, pts	–5 +10	0	2
Tensile, psi		2683	2911
Tensile Change, %	-25	7	11
Elongation, %		522	557
Elongation Change, %	-45	1	-9
Volume Change, %	-10	-9.1	-8.7
Aged in: IRM 903 Oil, 70 Hrs. @ 100°C			
Hardness, (A), pts.		46	43
Hardness Change, pts.	–10 +5	-7	-10
Tensile, psi		2378	2422
Tensile Change, %	-45	-5	-8
Elongation, %		471	536
Elongation Change, %	-45	-9	-13
Volume Change, %	25	9.6	10.3
Aged in: Fuel A, 70 Hrs. @ 23°C			
Hardness, (A), pts.		48	48
Hardness Change, pts.	±10	-5	-5
Tensile, psi		2326	2099
Tensile Change, %	-25	-7	-20
Elongation, %		507	527
Elongation Change, %	-25	-2	-14
Volume Change, %	-5 +10	1.3	3.2
Aged in: Fuel B, 70 Hrs. @ 23°C			
Hardness, (A), pts.		35	24
Hardness Change, pts.		-18	-19
Tensile, psi		792	735
Tensile Change, %		-68	-72
Elongation, %		228	264
Elongation Change, %		-56	-57
Volume Change, %		40.1	40.9

MOLDED GOODS COMPOUND
To Meet M2BG514B34EA14EF11EO14EO34F17
Continued

Aged in: Fuel C, 70 Hrs. @ 23°C			
Hardness, (A), pts.		33	35
Hardness Change, pts.		-20	-18
Tensile, psi		533	488
Tensile Change, %		-79	-81
Elongation, %		179	180
Elongation Change, %		-65	-71
Volume Change, %		66.8	64.2
Aged in: Distilled H_2O, 70 Hrs. @ 23°C			
Hardness, (A), pts.		50	49
Hardness Change, pts.	±10	-3	-4
Tensile, psi		2281	2384
Tensile Change, %		-9	-9
Elongation, %		455	521
Elongation Change, %		-12	-15
Volume Change, %	±15	4.4	3.1

MOLDED GOODS FORMULATION
To Meet M3CH614A25B14B34EO16EO36
Zeon

Nipol DN4080	100.00
Kadox 920C	5.00
Stangard 500	3.00
Spider Sulfur	0.50
Stearic Acid	1.00
N-774 Black	35.00
Plasthall 7050	5.00
TMTD	1.00
TETD	1.00
OBTS	1.00
Total	**152.50**
Processing Properties	
Mooney Viscosity	
ML (1+4) @ 100°C	64.0
Mooney Scorch: ML(1+30) @ 125°C	
Viscosity, min.	43.5
t5, minutes	5.4
t35, minutes	7.4
ODR: Microdie, 100 CPM, 3° Arc @ 170°C	
ML, dN-m	14.3
ML, (lbf-in)	16.2
MH, dN-m	75.1
MH, (lbf-in)	84.8
ts2, minutes	1.0
t'90, minutes	2.9
Cure, minutes	5.0
Vulcanized Properties	
Originals: Cured @ 170°C	
Hardness (A), pts.	62
Stress, 50%, MPa(psi)	1.4(196)
Stress 100%, MPa(psi)	2.0(287)
Stress 200%, MPa(psi)	4.4(639)
Tensile, MPa(psi)	25.4(3678)
Elongation, %	577

MOLDED GOODS FORMULATION
To Meet M3CH614A25B14B34EO16EO36
Continued

Compression Set: Method B	
22 Hrs. @ 100°C, Disc	22.2
22 Hrs. @ 100°C, Button	16.2
Aged Properties	
Aged in: Air Test Tube, 70 Hrs. @ 125°C	
Hardness, (A), pts.	66
Hardness Change, pts.	4
Tensile, psi	3076
Tensile Change, %	-16
Elongation, %	400
Elongation Change, %	-31
Aged in: ASTM #1 Oil, 70 Hrs. @ 150°C	
Hardness, (A), pts.	67
Hardness Change, pts.	5
Tensile, psi	2995
Tensile Change, %	-19
Elongation, %	446
Elongation Change, %	-23
Volume Change, %	-5.5
Aged in: IRM 903 Oil, 70 Hrs. @ 125°C	
Hardness, (A), pts.	61
Hardness Change, pts.	-1
Tensile, psi	3189
Tensile Change, %	-13
Elongation, %	454
Elongation Change, %	-21
Volume Change, %	3.1
Aged in: IRM 903 Oil, 70 Hrs. @ 150°C	
Hardness, (A), pts.	61
Hardness Change, pts.	-1
Tensile, psi	3144
Tensile Change, %	-15
Elongation, %	497
Elongation Change, %	-14
Volume Change, %	3.4

ASTM D-2000 SPECIFICATION – 3CH915A25B14E16E36
Goodyear

Chemigum N612	100.00
Zinc Oxide	5.00
Stearic Acid	0.50
FEF Carbon Black	70.00
MT Carbon Black	100.00
Paraplex G-25	5.00
Dioctyl Phthalate	3.00
Spider Sulfur	0.25
Methyl Tuads	3.00
Agerite Resin D	2.00
Total	**288.75**
Mooney Viscosity, ML-4'/212°F	**132+**
Mooney Scorch, MS/250°F	
MS Low	62
T3, Minutes	7.4
Original Physical Properties	
Tensile, psi	2075
Elongation, %	160
100% Modulus, psi	1425
Shore A Hardness	90
Specific Gravity	1.390
Compression Set, 22 Hrs. @ 212°F, %	5.8
Air Test Tube Aged 70 Hrs. @ 250°F	
Tensile, psi	2100
% Change	+5
Elongation, %	110
% Change	-31
Shore A Hardness	94
Points Change	+5

ASTM D-2000 SPECIFICATION – 3CH915A25B14E16E36 Continued

Aged ASTM #1 Oil 70 Hrs. @ 300°F	
Tensile, psi	1950
% Change	-2
Elongation, %	100
% Change	-37
Shore A Hardness	93
Points Change	+4
% Volume Change	-3.7
Aged ASTM #3 Oil 70 Hrs. @ 300°F	
Tensile, psi	1600
% Change	-20
Elongation, %	130
% Change	-19
Shore A Hardness	82
Points Change	-7
% Volume Change	+8.9

ASTM D-2000 SPECIFICATION – 2CH820A25B14E15E35F17
Goodyear

Chemigum N715B	100.00
Zinc Oxide	5.00
Stearic Acid	0.50
Agerite Resin D	2.00
FEF Carbon Black	60.00
MT Carbon Black	50.00
TP90B	10.00
Spider Sulfur	0.40
Methyl Tuads	2.00
Amax #1	1.00
Total	**230.90**
Mooney Viscosity, ML-4'/212°F	**82**
Mooney Scorch, MS/250°F	
MS Low	30.5
T3, Minutes	12.8
Original Physical Properties	
Tensile, psi	2400
Elongation, %	215
100% Modulus, psi	1150
Shore A Hardness	79
Specific Gravity	1.292
Compression Set, 22 Hrs. @ 212°F, %	8.8
Air Test Tube Aged 70 Hrs. @ 257°F	
Tensile, psi	2550
% Change	+5
Elongation, %	155
% Change	-35
Shore A Hardness	84
Points Change	+5

ASTM D-2000 SPECIFICATION – 2CH820A25B14E15E35F17 Continued

Aged ASTM #1 Oil 70 Hrs. @ 257°F	
Tensile, psi	2625
% Change	+8
Elongation, %	180
% Change	-25
Shore A Hardness	84
Points Change	+5
% Volume Change	-3.8
Aged ASTM #3 Oil 70 Hrs. @ 257°F	
Tensile, psi	2450
% Change	+1
Elongation, %	185
% Change	-23
Shore A Hardness	72
Points Change	-7
% Volume Change	+12.1
Solenoid Brittleness	-58.9

ROLLS
Various hardness
Enichem

		1	2	3	4	5
Europrene N 3345		70	70	80	100	100
Europrene N 3380		30	30	20		
ZnO		5	5	5	5	5
N 550 FEF		15	20	30	25	40
N 762 SRF					25	40
Calcium carbonate		20	20	20		
Stearic acid		1	1	1	1.5	2
Anox HB		1	1	1	1	1
DOP		75	60	40	5	
Plasticizer SC		25	20	20	5	5
Coumarone resin (m.p.25°C)						5
Factis NQ		40	40	30		
Sulphur		1.5	1.5	1.5	2	2
MBTS		1.5	1.5	1.5	1.5	1
TMTM		0.5	0.5	0.3	0.2	0.2
Mooney Compound (1+4) 100°C		5	10	14	36	62
Density	gr/cm^3	1.09	1.10	1.14	1.18	1.25
Press cure 30 min at 150°C						
T.S.	MPa	1.8	2.6	4.7	17.0	18.0
E.B.	%	520	480	550	440	305
Hardness ShA	points	22	28	36	65	78
Abrasion DIN (250gr)	mm^3		283	205		
(500gr)	mm^3				87	101

ROLL COMPOUNDS

Uniroyal

	1	2	3
Paracril® BJLT-M50	100.0	100.0	----
Paracril ®OZO-M50	----	----	100.0
Neophax A	10.0	10.0	10.0
Zinc Oxide	20.0	20.0	20.0
Stearic Acid	1.0	1.0	1.0
HAF (N-330) Black	60.0	----	----
Hi Sil 233	----	25.0	25.0
Cumar P-10	15.0	15.0	15.0
Dibutyl Phthalate	25.0	15.0	25.0
Mistron Vapor Talc	----	50.0	50.0
Spider Sulfur	2.0	2.0	2.0
MBTS	1.5	1.5	1.5
Monex®	0.3	0.3	0.3
Total	**234.8**	**249.8**	**249.8**
Mooney Viscosity			
ML (1+4) @ 100°C(212°F)	30	34	37
ML (1+4) @ 121°C(250°F)	14	14	15
Mooney Scorch, MS @ 121°C(250°F)			
Scorch Time, t3, minutes	15.0	29.8	26.0
Cure Rate	3.5	3.5	3.2
Unaged Physical Properties			
Cured 30 Minutes @ 149°C(300°F)			
Hardness, Shore A	62	62	70
Tensile Strength, MPa(psi)	20.0	15.0	11.4
	(2900)	(2170)	(1650)
Elongation, %	450	690	525
Abrasion Index, Bureau of Standards	160	41	50

DUROMETER 95 COMPOUND FOR ROLLS
PPG

NBR 683	100.0
HSR S6B	10.0
Ciptane 255LD	77.0
CI 25°C Resin	10.0
DOP	5.0
ODPA Antioxidant	1.0
Sulfur	5.0
Zinc Oxide	1.0
TBBS	2.0
HMT	2.0
DPTH	1.0
Specific Gravity	1.28
Cure Rate 150C, MDR T50	6.7 minutes
Mooney Scorch, 121C, T5	10 minutes
Mooney Viscosity, ML100	120
Durometer (Cured 40’/150C)	
at 23C	96
at 100C	90
Abrasion Tests	
NBS Index	175
PICO @ 100C	11 mg loss*
*normal NBR cure loss 20-40 mg	
Goodrich Flexometer, 100C, 15%; 1 MPa	
Static Compression	1.9%
Dynamic Drift	4.8%
Permanent Set	7.8%
Heat Build-Up	20°C
Stress-Strain	
M20, Mpa	4.9
M300	12.7
Tensile	28
Elongation	210%
Pendulum Rebound (Z), %	
at 23C	21
at 100C	90

DUROMETER 88 COMPOUND FOR ROLLS
PPG

NBR 34-35		100.0
Hi-Sil 532EP		30.0
Hi-Sil 233		10.0
Treated Clay		25.0
Titanium Dioxide		5.0
TMQ		2.0
Stearic Acid		1.0
Zinc Oxide		5.0
Sulfur		0.1
Saret 500		15.0
BPDIB 40%		3.6
Specific Gravity		1.18
Cure Rate 160C, MDR T50		12
Mooney Scorch, 121C, T5		30+
Mooney Viscosity, ML100		38
Cure: 45’/160C		
Durometer: 23C		88
100C		85
	Original	Aged 170 hrs/125C
Durometer	88	92
M20, Mpa	3.9	5.7
M100	12	
Tensile	15	17
Elongation, %	150	100
MG Trouser Tear, kN/m		7.7
PICO Abrasion Index		104
NBS Abrasion Index		90
Compression Set, 70 hours @ 100C, %		21
Goodrich Flexometer, 100C; 22.5%; 1 MPa:		
Static Compression, %		5.0
Permanent Set		1.1
Heat Build-Up		28°C
Pendulum Rebound (Z), %:		
at 23C		24
at 100C		58

70 SHORE A ROLL COMPOUNDS
Uniroyal

	Black	Non-Black
Paracril® BPLT	----	100.0
Paracril® BJLT-M50	100.0	----
Neophax A	10.0	----
Amberex B	----	10.0
Stearic Acid	1.0	1.0
Aminox®	1.5	----
Octamine®	1.5	----
Naugawhite® Powder	----	2.0
Zinc Oxide	5.0	5.0
SRF (N-774) Black	130.0	----
Zeolex #23	----	56.0
Purecal U	----	130.0
Cumar P-10	15.0	----
TP-95	----	15.0
Dibutyl Phthalate	25.0	----
Spider Sulfur	2.0	----
Monex®	0.3	----
MBTS	1.5	2.0
Tuex®	----	1.0
Naugex® SD-1	----	2.0
Total	**292.8**	**325.0**
Mooney Viscosity		
ML (1+4) @ 100°C(212°F)	47	86
Mooney Scorch, MS @ 121°C(250°F)		
Scorch Time, t3, minutes	22.0	8.2
Cure Rate, minutes	4.2	9.5
Unaged Physical Properties		
Cured 15 Minutes @ 171°C(340°F)		
Hardness, Shore A	72	71
Tensile Strength, MPa(psi)	14.2(2060)	5.8(840)
Elongation, %	300	390
Tear, Die C, kN/m (lb/in)	50(290)	24(140)
Aged 5 Hourss @ 65°C(150°F)		
Hardness, Shore A	72	75

NON-BLACK PRINTING ROLLS
Enichem

		1	2	3	4	5
Europrene N 3345		100	100	100	70	100
Europrene N 33R70					30	
Factis NQ		90	15	15		
ZnO		5	5	5	5	5
Stearic acid		1	1	1	1	1
Zeolex 25		30	25	40	75	80
Socal U		15	30	50		15
Titanium dioxide		5	5	5	5	10
DOP		90	35	30	2.5	8
Vulkanol FH		5	5	5	5	8
DEG		1.5	1.5	2	4	4
Picco 50			2	3	4	5
Octamine		1	1	1	1	1
Vulkanox HS		1.5	1.5	1.5	1.5	1.5
MBTS		1.8	1.5	1.5	1.5	1.5
TMTM		1	0.75	0.75	0.75	0.5
Sulphur		1.5	3	3	1.5	1.5
Steam cured 40 min at 4 bar						
Hardness ShA	points	25±5	50±5	60±5	70±5	80±5

NON-BLACK ROLLS 95 ShA
Enichem

Europrene N 3945		100
ZnO		5
Stearic acid		1
Zeolex 25		50
Ultrasil VN3		25
DEG		2.3
Saret 500		12
Vulkanox HS		2
Dicup 40		6
Press cure 15 min at 165°C		
Hardness ShA	points	92

90 DUROMETER NON-BLACK ROLLS & GENERAL PURPOSE
Goodyear

	1	2	3	4
Chemigum NX775	100.00	75.00	65.00	75.00
Chemigum N683B	0.00	25.00	25.00	0.00
Natsyn 2200	0.00	0.00	10.00	25.00
Chlorobutyl HT 1068	0.00	0.00	0.00	0.00
Plioflex 1502	0.00	0.00	0.00	0.00
Hi-Sil 243LD	30.00	30.00	30.00	30.00
Hi-Sil 532EP	20.00	20.00	20.00	20.00
Dioctyl Phthalate	5.00	5.00	5.00	5.00
Durez 12686	12.00	12.00	12.00	12.00
Stearic Acid	3.00	3.00	3.00	3.00
Wingstay L	2.00	2.00	2.00	2.00
Kadox 911C ZnO	5.00	5.00	5.00	5.00
Unads (TMTM)	1.50	1.50	1.50	1.50
Sulfur, Spider Brand	1.50	1.50	1.50	1.50
Wingstay 100	0.50	0.50	0.50	0.50
DOTG	0.50	0.00	0.00	0.00
HEXA Powder	0.75	0.75	0.75	0.75
Total	**181.75**	**181.25**	**181.25**	**181.25**
Rheometer, 320°F, 3° Arc, 100 CPM, 60 Min. Motor				
Torque, Min.	7.5	7.5	8.5	9.0
Torque, Max.	80.0	82.5	69.5	60.5
TS 2, minutes	2.5	2.3	2.7	2.7
T'C 90, minutes	23.5	8.3	10.0	22.5
T'C 95, minutes	37.0	12.7	21.7	35.0
Rheometer, 360°F, 3° Arc, 100 CPM, 60 Min. Motor				
Torque, Min.	6.5	7.0	7.5	8.5
Torque, Max.	79.5	70.5	63.0	58.0
TS 2, minutes	1.3	1.1	1.2	1.3
T'C 90, minutes	15.5	4.5	6.8	10.5
T'C 95, minutes	27.1	8.3	12.5	16.5
Scorch, M/S @ 250°F(121°C)				
Minimum	20.0	19.0	19.0	20.0
20 Min. Reading	22.0	----	20.5	20.7
T5, minutes	----	17.5	----	----

90 DUROMETER NON-BLACK ROLLS & GENERAL PURPOSE Continued

SPECIFIC GRAVITY	1.218	1.222	1.211	1.200
Original Physical Properties				
Tensile, psi	3216	3100	2746	2315
Elongation, %	350	378	344	268
50% Modulus, psi	898	837	804	973
100% Modulus, psi	1309	1242	1154	1343
300% Modulus, psi	2825	2631	2441	----
Shore A Hardness	90	90	91	92
Pico Abrasion				
Index, %	594	438	283	138
Taber Abrasion, H-18 Wheel, 10K Revolutions, 1 KGM Weight				
Loss, MBM-Vol/1J Rev:	167.5	189	168.5	256.7
Din Abrasion Index, Rel. Vol. Loss				
MM^3	119.3	134.2	150.4	182.2

90 DUROMETER NON-BLACK ROLLS & GENERAL PURPOSE

Goodyear

	5	6	7
Chemigum NX775	75.00	100.00	100.00
Chemigum N683B	0.00	0.00	0.00
Natsyn 2200	0.00	0.00	0.00
Chlorobutyl HT 1068	0.00	15.00	0.00
Plioflex 1502	25.00	0.00	0.00
Hi-Sil 243LD	30.00	30.00	30.00
Hi-Sil 532EP	20.00	20.00	20.00
Dioctyl Phthalate	5.00	0.00	5.00
Durez 12686	12.00	15.00	12.00
Stearic Acid	3.00	3.00	3.00
Wingstay L	2.00	2.00	2.00
Kadox 911C ZnO	5.00	5.00	5.00
Unads (TMTM)	1.50	1.50	1.50
Sulfur, Spider Brand	1.50	1.50	1.50
Wingstay 100	0.50	0.50	0.50
DOTG	0.00	0.00	0.00
HEXA Powder	0.75	0.75	0.75
Total	**181.25**	**194.25**	**181.25**
Rheometer, 320°F, 3° Arc, 100 CPM, 60 Min. Motor			
Torque, Min.	10.5	11.0	8.0
Torque, Max.	69.5	76.5	86.0
TS 2, minutes	2.6	3.5	3.0
T'C 90, minutes	21.0	34.2	32.0
T'C 95, minutes	35.0	44.0	43.5
Rheometer, 360°F, 3° Arc, 100 CPM, 60 Min. Motor			
Torque, Min.	9.5	10.0	8.0
Torque, Max.	70.0	76.5	84.5
TS 2, minutes	1.3	1.7	1.4
T'C 90, minutes	17.0	19.0	15.5
T'C 95, minutes	31.0	31.0	25.0
Scorch, M/S @ 250°F(121°C)			
Minimum	23.0	27.0	23.0
20 Min. Reading	25.5	28.6	23.7
T5, minutes	----	----	----

90 DUROMETER NON-BLACK ROLLS & GENERAL PURPOSE Continued

SPECIFIC GRAVITY	1.207	1.198	1.221
Original Physical Properties			
Tensile, psi	2655	2864	3412
Elongation, %	319	306	379
50% Modulus, psi	892	983	833
100% Modulus, psi	1261	1405	1233
300% Modulus, psi	2507	2822	2801
Shore A Hardness	91	92	91
Pico Abrasion			
Index, %	175	271	665
Taber Abrasion, H-18 Wheel, 10K Revolutions, 1 KGM Weight			
Loss, MBM-Vol/1J Rev:	256.0	172.0	144.1
Din Abrasion Index, Rel. Vol. Loss			
MM^3	171.4	131.1	115.1

75 DUROMETER NON-BLACK FOR ROLL APPLICATIONS

Goodyear

Chemigum NX775	80.00
Chemigum N685B	20.00
Mistron Vapor	25.00
Carbowax 3350	0.30
Wingstay L	2.00
Cumar NH 2-1/2	4.00
Stearic Acid	1.50
TMTD	2.00
MBTS	2.00
Sulfur, Spider Brand	0.50
Kadox 911C Zinc Oxide	7.00
Total	**144.30**
Rheometer, 310°F(155°C), 3° Arc, 100 CPM, 60 Min. Motor	
Torque, Min.	5.0
Torque, Max.	68.0
TS 2, minutes	4.8
T'C 80, minutes	11.7
T'C 90, minutes	14.9
Specific Gravity	1.118
Scorch, MS/250°F(121°C)	
Minimum	11.0
20 Min. Reading	11.5
Original Physical Properties, Cured 325°F (163°C)	
Tensile, psi	2835
Elongation, %	425
100% Modulus, psi	632
200% Modulus, psi	884
Hardness, Shore A	74
Din Abrasion	
Rel. Vol. Loss (mm^3)	125

NON-BLACK ROLLS 70 SHA
Enichem

Recipe		
Europrene N3330		100
ZnO		5
Stearic acid		1
Ultrasil VN3		50
DBP		13
MBTS		1.5
Vulkalent A		1
Sulphur		3
Press cure 30 min at 150°C		
T.S.	MPa	19.5
E.B.	%	650
Hardness ShA	points	70
Compression set	%	26

40 DUROMETER NON-BLACK ROLL FORMULATION

Goodyear

Chemigum NX775	100.00
Hi-Sil 243LD	17.00
Multiflex MM	12.50
Titanium Dioxide	12.50
Factice	10.00
Wingstay L	1.00
Stearic Acid	0.68
Dioctyl Phthalate	19.50
Tricresyl Phosphate	32.00
Sulfur, Spider Brand	1.10
Unads	1.10
Ethyl Tuads	0.66
Kadox 911C Zinc Oxide*	7.50
Total	**215.54**
Rheometer, 325°F, 3° Arc, 100 CPM, 60 Min. Motor	
Torque, Min.	2.5
Torque, Max.	30.3
TS 2, minutes	5.3
T'C90, minutes	22.5
T'C95, minutes	36.0
Scorch, MS/250°F	
Minimum	4.0
T5, minutes	30.0+
30 minutes reading	4.0
Original Properties	
Tensile, psi	1375
Elongation, %	735
Hardness, Shore A	43
Tear, Die-C, ppi	99

*****Since Zinc Oxide is a curative for Chemigum NX775, it must be incorporated with the accelerators late in the mix.

40 DUROMETER NON-BLACK ROLL FORMULATION Continued

Circ. Air Oven Aging - 70 Hrs./212°F	
Tensile, psi	625
% Change	-55
Elongation, %	430
% Change	-41
Hardness, Shore A	48
Points Change	+5

NON-BLACK ROLL COMPOUNDS
Zeon

	1	2	3	4	5
Nipol 1031	100.0	100.0	100.0	100.0	100.0
Zinc Oxide	5.0	5.0	5.0	5.0	5.0
Spider Sulfur	2.0	2.0	2.0	2.0	2.0
Agerite Superlite	2.0	2.0	2.0	2.0	2.0
Stearic Acid	1.0	1.0	1.0	1.0	1.0
HiSil 215	25.0	25.0	55.0	70.0	95.0
Pyrax A	10.0	10.0	10.0	10.0	10.0
Picco 25	----	----	----	15.0	15.0
Nipol 1312	35.0	25.0	20.0	25.0	30.0
DOP	10.0	10.0	10.0	----	----
TMTM	0.6	0.6	0.6	0.6	0.6
TMTD	0.1	0.1	0.1	0.1	0.1
Diethylene Glycol	1.0	1.0	1.0	1.0	1.0
Total	**211.7**	**201.7**	**206.7**	**231.7**	**261.7**
Typical Physical Properties					
Tensile, psi	1420	2020	2970	210	1670
100% Modulus,psi	30	30	100	80	80
Elongation %	900	800	750	800	710
Hardness Shore A	50	60	70	75	80

SOLES WITH HIGH SOLVENT RESISTANCE
Enichem

Europrene N 4560		100
ZnO		5
Stearic acid		1
N 990 MT		40
DOP		10
N 220 ISAF		30
Vulkanox HS		2
Vulkanox MB		2
CBS		2
TMTD		2
Sulphur		0.3
Press cure 10 min at 165°C		
T.S.	MPa	15.8
E.B.	%	550
Hardness ShA	points	65
Compression set 22h 70°C	%	11.5
Abrasion resistance (BS 903)		1.68
Ageing in Air 96h at 100°C		
Δ T.S.	%	0
Δ E.B.	%	-30
Δ ShA	points	7
Ageing in HCl 30% 72h at 20°C		
Δ T.S.	%	1.5
Δ E.B.	%	-20
Δ ShA	points	-2
Δ Volume	%	3
Ageing in SAE 40 72h at 100°C		
Δ T.S.	%	-10
Δ E.B.	%	-40
Δ ShA	points	3
Δ Volume	%	-3
Ageing in Petrol 48h at 20°C		
Δ T.S.	%	-20
Δ E.B.	%	-20
Δ ShA	points	-3
Δ Volume	%	4.5

ANTISTATIC SOLES

Enichem

Europrene N 3380		100
ZnO		5
Stearic acid		1
N 772 SRF		40
Vulkanol 85		10
Coumarone resin		5
MBTS		1.5
TMTM		0.3
Sulphur		1.5
Ketjenblack EC 300 J		5
Vulkanox HB		1.5
Press cure 10 min at 160°C		
T.S.	MPa	16.2
E.B.	%	440
Hardness ShA	points	63
DeMattia test	cycles	15000
Abrasion (DIN)		99
Volume resistivity	Ohm/cm	240000
Ageing in Trimethylpentane 22h at 23°C		
Δ Volume	%	10
Ageing Water 7 days at 70°C		
Δ T.S.	%	-6
Δ E.B.	%	-13
Δ Volume	%	3

OIL RESISTANT SOLES
Enichem

Europrene N 3345		100	100
ZnO		5	5
Stearic acid		0.5	1
N 772 SRF		-	100
DOP		-	15
Ultrasil VN3		40	-
Resin 731 D		3	-
Vulkanox HS		-	1.5
Resin 422 R		-	5
MBTS		0.4	1.5
TMTD		1.5	2.5
Sulphur		1.8	0.35
Press cure 7 min at 180°C			
T.S.	MPa	21.2	14.4
E.B.	%	612	375
Hardness ShA	points	73	63
Abrasion (BS 903)		2.2	1.5
Ageing in Sulphuric acid 10% 48h at 23°C			
Δ ShA	points	-1	0
Δ Volume	%	0.5	0
Ageing in NaOH 10% 48h at 23°C			
Δ ShA	points	-32	1
Δ Volume	%	11	0
Ageing in ASTM #1 oil 48h at 70°C			
Δ ShA	points	4	2
Δ Volume	%	0	-2.5
Ageing in ASTM #3 oil 48h at 70°C			
Δ ShA	points	3	1
Δ Volume	%	3	0.5
Ageing in Petrol 48h at 23°C			
Δ ShA	points	-9	-1
Δ Volume	%	16	11
Ageing in Kerosene 48h at 23°C			
Δ ShA	points	1	1
Δ Volume	%	1	1
Ageing in Air 48h at 70°C			
Δ T.S.	%	0	3
Δ E.B.	%	-11	3
Δ ShA	points	7	1

CHEMICAL RESISTANT SOLES

Enichem

		1	2
Europrene N 2845		100	
Europrene N 3345			100
ZnO		5	5
Stearic acid		1	1
N 330 HAF		95	95
Silteg AS7		45	45
Coumarone Resin 85		5	5
Struktol KW400		8	8
Vulkanox 4010NA		1.5	1.5
DEG		1	1
TMTD		2.5	2.5
CBS		1.5	1.5
Sulphur		0.2	0.2
Mooney Compound (1+4) 100°C		64	60
Scorch at 121°C			
MV	lb*inch	40	38
T5	min	9.5	8.3
T35	min	13.7	12.7
Rheometer 160°C, 24’, arc ± 1°			
ML	lb*inch	5.8	5.6
MH	lb*inch	45.1	44.7
TS1	min	1.6	1.6
T50	min	3.9	4
T90	min	6.1	6
Press cure 7 min at 160°C			
M100	MPa	2.4	2.4
M300	MPa	8.0	8.1
T.S.	MPa	12.5	12.9
E.B.	%	455	465
Hardness ShA	points	68	6.7
Ageing in Air 70h at 70°C			
Δ M100	%	19	18
Δ M300	%	14	15
Δ T.S.	%	3	5
Δ E.B.	%	-7	-7
Δ ShA	points	4	5
Δ Weight	%	-2	-2

CHEMICAL RESISTANT SOLES
Continued

		1	**2**
Ageing in Hydrochloric acid 10% 168h at 25°C			
Δ M100	%	-16	-12
Δ M300	%	-9	-6
Δ T.S.	%	6	11
Δ E.B.	%	8	10
Δ ShA	points	-5	-4
Δ Weight	%	4	4
Δ Volume	%	6	6
Ageing in Sulphuric acid 10% 168h at 25°C			
Δ M100	%	-13	-13
Δ M300	%	-10	-7
Δ T.S.	%	3	2
Δ E.B.	%	5	3
Δ ShA	points	-5	-3
Δ Weight	%	4	5
Δ Volume	%	5	5
Ageing in NaOH 10% 168h at 25°C			
Δ M100	%	-21	-13
Δ M300	%	-14	-5
Δ T.S.	%	1	5
Δ E.B.	%	6	3
Δ ShA	points	-5	-4
Δ Weight	%	4	3
Δ Volume	%	4	3
Ageing in Na hydrophosphate 10% 168h at 25°C			
Δ M100	%	-17	-17
Δ M300	%	-9	-7
Δ T.S.	%	8	7
Δ E.B.	%	8	5
Δ ShA	points	-6	-4
Δ Weight	%	5	5
Δ Volume	%	6	6

DUROMETER 68 COMPOUND FOR SOLING
PPG

NBR 40% ACN	50.0
XNBR NX775	25.0
BR 1220	25.0
Hi-Sil 210	15.0
Ciptane I	20.0
DOP	5.0
DOS	10.0
HPPD	2.0
MC Wax	1.0
Zinc Oxide	3.0
Stearic Acid	2.0
Sulfur	2.0
TBBS	2.0
DPTH	1.0
HMT	1.0
Specific Gravity	1.13
MDR 150C: T2 Scorch, minutes	2.8
T90 Cure, minutes	6.4
Viscosity, ML100	46
Cure: 15’/150C	
Durometer: at 23C	68
at 100C	65
Stress/Strain	
M300, Mpa	11.5
Tensile	12
Elongation, %	300
Abrasion Indices: NBS	510
PICO	196
Fuel B, 48 hours 23C, % swell	26
Compression Set, 70 hours 100C	61%
Pendulum Rebound (Z), % at 23C	32
at 100C	65

DUROMETER 63 COMPOUND FOR SOLING
PPG

NBR 40E65				60.0
BR 1220				40.0
Hi-Sil/Ciptane				35.0
DOP				5.0
DOA				10.0
MC Wax				1.0
HPPD				2.0
Stearic Acid				1.0
Sulfur				2.0
TBBS				2.0
DPTH				2.0
HMT				1.0
Total				161.0
Specific Gravity				1.11
Silica		Hi-Sil 210		Ciptane I
Cure Rate 150C, T50’		8.2		8.3
Mooney Scorch 121C, T5’		28		26
Viscosity, ML100		44		41
Cure: 20’/150C	Original	Aged 3d/125C	Original	Aged
Durometer	64	86	62	85
M300, MPa	4.1	--	6.3	--
Tensile	12	5.3	13	5.6
Elongation	595	40	470	40
Abrasion Index: PICO/NBS		72/230		88/440
Compression Set, 72 hrs./100C		86		84
Fuel B 48 hrs 23C, % Swell		31.0		30.4
Dynamic Properties				
Pendulum Rebound (Z), %: 23C		34		34
100C		67		68
Cut Growth, kC to 500%: Ross		70		100+
DeMattia		100+		18
Goodrich Flexometer: 100C, 22.5%, 1MPa				
Set, %		16		13
Heat Build-Up,C		30		23
Dynamic Mechanical Analysis: 0C; 1Hz; 15% Deflection				
E’, MPa		15		13

DIRECT MOLDED MICRO-CELLULAR SOLES

Uniroyal

Paracril® OZO M50		100.0	
Octamine®		1.0	
Zinc Oxide		3.0	
Turgum S		3.0	
Stearic Acid		1.0	
Silene EF		25.0	
Hard Clay		50.0	
Dioctyl Phthalate		20.0	
Petrolatum		8.0	
MBTS		1.0	
MBT		0.5	
DOTG		1.0	
Spider Sulfur		3.0	
Methazate®		0.5	
Celogen® OT		1.5 to 5.0	
Total		**218.5 to 222.0**	
Cure @ 160°C(320°F)	**5 Min.**	**7.5 Min.**	**10 Min.**
Density, kg/m^3 (lb/ft^3)	331.2(20.7)	496.0(31.0)	540.8(33.8)
25% Compression			
Deflection, kN/m^2(psi)	98.9	175.2	187.6
	(14.3)	(25.4)	(27.2)
Hardness, Shore A	30	42	45

OIL WELL PACKERS
Uniroyal

	1	2
Paracril® CLT	100.0	100.0
Zinc Oxide	5.0	5.0
Stearic Acid	1.0	1.0
Aminox®	1.5	1.5
Hi-Sil EP	55.0	----
Carbon Black S-315	----	50.0
Cumar P-25	10.0	10.0
DOP	10.0	10.0
Tuex®	1.5	1.5
Ethyl Tuex®	1.5	1.5
Delac® S	2.0	2.0
Naugex® SD-1	1.5	0.5
Unaged Physical Properties		
Cured 60 minutes @ 154°C(310°F)		
300% Modulus, MPa (psi)	3.7(540)	8.0(1160)
Tensile Strength, MPa (psi)	7.2(1050)	17.1(2480)
Elongation, %	680	630
Hardness, Shore A	61	65
Tear, Die C, kN/m (lb/in)	40.2(230)	61.2(350)
Hot Tear 100°C(212°F), kN/m (lb/in)	26.2(150)	42.0(240)
Brittle Point, °C (°F)	-20(-4)	-26(15)
Oven Aged 70 hours @ 149°C(300°F)		
300% Modulus, MPa (psi)	15.8(2290)	----
Tensile Strength, MPa (psi)	17.4(2520)	9.6(1390)
Tensile Strength, % Change	+140	-44
Elongation, %	390	65
Elongation, % Change	-43	-87
Hardness, Shore A	84	92
Hardness, Points Change	+23	+27
Aged 168 Hours in ASTM Oil #3 @ 149°C(300°F)		
Tensile Strength, MPa (psi)	18.3(2660)	23.4(3400)
Tensile Strength, % Change	+153	+37
Elongation, %	690	580
Elongation, % Change	+2	-8
Hardness, Shore A	75	74
Hardness, Points Change	+14	+9
% Volume Swell	-4.4	-4.4

90 DURO DOWNHOLE PACKER COMPOUND
Zeon

Nipol 1051	100.0	
Zinc Oxide	5.0	
Stearic Acid	1.0	
Agerite Resin D	1.0	
N-231 ISAF-LM	35.0	
N-774 SRF-HM-NS	50.0	
Cab-O-Sil MS-7SD	15.0	
Saret 500	5.0	
Spider Sulfur	1.0	
SI-69	1.0	
TMTD	1.0	
MBTS	1.0	
Total	**216.0**	
Processing Properties		
Mooney Viscometer, Large Rotor, 125°C – ASTM D 1646		
Viscosity, minimum	129.0	
t5, minutes	8.2	
t35, minutes	9.2	
Rheometer, Micro Die, 100° CPM, 1° Arc, 170°C – ASTM D 2084		
ML, lbf. in.	18.0	
MH, lbf. in.	75.0	
ts1, minutes	1.0	
t'90, minutes	12.5	
t'90 x 1.25, minutes	15.6	
Cure Time, minutes	16.0	
Vulcanizate Unaged Properties		
Originals: Cured @ 170°C		
Stress 100%, (psi) MPa (a)	(1550)	10.69
Stress 200%, (psi) MPa (a)	(3500)	24.13
Stress 300%, (psi) MPa (a)	(----)	
Tensile Strength, (psi) MPa (a)	(3800)	26.20
Ultimate Elongaton, % (a)	210	
Hardness Duro A, pts. (b)	87	

90 DURO DOWNHOLE PACKER COMPOUND
Continued

Stress/Strain @ 125°C		
Tensile Strength, (psi) MPa (a)	(1790)	12.34
Ultimate Elongation, % (a)	280	
Hardness Duro A, pts. (b)	80	
(a) ASTM D 412		
(b) ASTM D 2240		
Tear, Die C, W/G – ASTM D 624		
R.T., ppi	250	
125°C, ppi	102	
150°C, ppi	60	
Compression Set, Method B, Buttons – ASTM D 395		
70 Hrs. @ 100°C, % Set	37	
70 Hrs. @ 150°C, % Set	77	
Pico Abrasion, 4.5 kgs. 60 RPM, 40-40 Rev. – ASTM D 228		
Specific Gravity	1.316	
Abrasion Loss, Relative Index, %	525	
ASTM Brittleness Test, ASTM D 2137		
Tp, ° C	-14	
Aged Properties		
Air Age Test Tube; 70 Hrs. 125°C – ASTM D 865		
Tensile Strength, (psi) MPa	(3350)	23.10
Tensile Change, %	-12	
Ultimate Elongation, %	120	
Elongaton Change, %	-43	
Hardness Duro A, pts.	89	
Hardness Change, pts.	+2	
Weight Change, %	-0.94	
Immersion Properties		
ASTM 3 Oil Immersion, 70 Hrs., 125°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3950)	27.24
Tensile Change, %	+4	
Ultimate Elongation, %	180	
Elongaton Change, %	-14	
Hardness Duro A, pts.	88	
Hardness Change, pts.	+1	
Volume Change, %	4.39	

90 DURO DOWNHOLE PACKER COMPOUND
Continued

Distilled H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3750)	25.86
Tensile Change, %	-1	
Ultimate Elongation, %	160	
Elongation Change, %	-24	
Hardness Duro A, pts.	85	
Hardness Change, pts.	-2	
Weight Change, %	6.5	
Volume Change, %	7.5	
5% KW-44/H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(4500)	31.03
Tensile Change, %	+18	
Ultimate Elongation, %	200	
Elongation Change, %	-5	
Hardness Duro A, pts.	78	
Hardness Change, pts.	-16	
Weight Change, %	15	
Volume Change, %	18	
Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3350)	23.10
Tensile Change, %	-12	
Ultimate Elongation, %	190	
Elongation Change, %	-10	
Hardness Duro A, pts.	71	
Hardness Change, pts.	-16	
Weight Change, %	14.0	
Volume Change, %	19.0	
5% K-147/Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3500)	24.13
Tensile Change, %	-8	
Ultimate Elongation, %	200	
Elongation Change, %	-5	
Hardness Duro A, pts.	70	
Hardness Change, pts.	-17	
Weight Change, %	19.0	
Volume Change, %	27.0	

PACKERS
DSM

	1	2
Nysyn 30-8	100.0	100.0
N-330 Black	40.0	40.0
Vulkanol OT	10.0	10.0
Zinc Oxide	5.0	5.0
Cabosil MS-7	35.0	35.0
Harwick DSC-18	0.75	0.75
Stearic Acid	1.0	1.0
MBTS	1.5	0
Suflur	1.5	0.5
Agerite Resin D	1.0	1.0
Santoflex 13	1.0	1.0
OBTS	0	2.0
TETD	0	1.0
TMTD	0	1.0
Total	196.75	198.25
Physical Properties		
Mooney Scorch @ 132°C		
Min. to 5 Pt. Rise	27.8	8.4
Minimum Reading	66	90
Press Cure @ 176°C, 8 min. cure		
Tensile, MPa	12.9	18.2
Elongation, %	420	259
100% Modulus, MPa	2.5	5.7
200% Modulus, MPa	6.2	13.6
300% Modulus, MPa	9.8	19
Hardness, Shore A	76	80
Compression Set		
70 Hrs. @ 125°C, 10 min. cure	85.9	41.4
After Air Oven Aging 70 Hrs. @ 125°C, 8 min. cure		
Tensile, % Change	+59	+4.3
Elongation, % Change	-47	-15
Hardness, Pts. Change	+12	+7
After Immersion in ASTM Oil #3 70 Hrs. @ 100°C, 8 min. cure		
Tensile, % Change	+33	+7
Elongation, % Change	-16	+11
Hardness, Pts. Change	-4	-6
Volume Change, %	+14	+36

PACKERS
Continued

After Immersion in ASTM Oil #1 70 Hrs. @ 100°C, 8 min. cure		
Tensile, % Change	+65	+20
Elongation, % Change	-17	+4
Hardness, Pts. Change	+9	+2
Volume Change, %	-3.9	-3.5
After Immersion in ASTM Fuel B 70 Hrs. @ 23°C, 8 min. cure		
Tensile, % Change	-55	-46
Elongation, % Change	-53	-20
Hardness, Pts. Change	-21	-18
Volume Change, %	+31	+31
After Immersion in ASTM Fuel C 70 Hrs. @ 23°C, 8 min. cure		
Tensile, % Change	-65	-60
Elongation, % Change	-62	-57
Hardness, Pts. Change	-35	-24
Volume Change, %	+63	+53
Low Temperature		
Brittle Point, °C, 8 min. cure	F@-50	F@-49

HIGH TEMPERATURE OIL WELL CABLE JACKET
Uniroyal

	1	2
Paracril® BJLT M50	100.0	----
Paracril® CJLT	----	100.0
Zinc Oxide	5.0	5.0
Stearic Acid	1.0	1.0
Octamine®	3.0	3.0
Paraplex G-33	20.0	20.0
MBTS	2.5	2.5
Ethyl Tuex®	1.5	1.5
Tuex®	1.5	1.5
Sulfur	0.2	0.2
Hi-Sil 243LD	40.0	40.0
Hard Clay	35.0	35.0
Unaged Properties – Press Cure – 1 minute @ 204°C(400°F)		
Tensile Strength, MPa (psi)	15.1(2190)	15.2(2200)
Elongation, %	840	790
Stress – 200%, MPa (psi)	1.3(190)	1.3(190)
Hardness, Shore A	63	68
Split Tear, kN/m (lb/in.)	8.8(50)	8.8(50)
7 Days ASTM #3 Oil @ 175°C(347°F)		
Tensile Strength, % Retained	75	96
Elongation, % Retained	52	46
Volume Swell	+4	-5
Hardness, Shore A, Change	+17	+12
Press Cure – 10 minutes @ 154°C(310°F)		
Tensile Strength, MPa (psi)	15.9(2300)	15.5(2250)
Elongation, %	780	750
Stress – 200%, MPa (psi)	1.5(210)	1.6(230)
Hardness, Shore A	63	67
7 Days ASTM #3 Oil @ 175°C(347°F)		
Tensile Strength, % Retained	72	89
Elongation, % Retained	51	47
Hardness, Shore A, Change	+17	+12
Mooney Viscosity ML-4 @ 100°C(212°F)	68	54
Mooney Scorch @ 121°C(250°F), minutes	20	23

OIL WELL CABLE JACKET COMPOUND

Zeon

Nipol 1051	100.0	
Zinc Oxide	5.0	
Stearic Acid	1.0	
Mistron Vapor	70.0	
Hi-Sil EP	10.0	
N-774 SRF-HM-NS	5.0	
Maglite D	5.0	
Stangard 500	2.0	
Antozite 67F	2.0	
Sunolite 240	3.0	
Paraplex G-62	5.0	
Spider Sulfur	0.4	
TMTD	1.5	
Sulfasan R	1.0	
WB-212	2.0	
Total	**212.9**	
Processing Properties		
Mooney Viscometer, Large Rotor, 125°C – ATM D 1646		
Viscosity, minimum	32.0	
t5, minutes	13.2	
t35, minutes	15.9	
Rheometer, Micro Die, 100° CPM, 1° Arc, 170° C – ASTM D 2084		
ML, lbf. in.	5.0	
MH, lbf. in.	24.0	
ts2, minutes	1.6	
t'90, minutes	3.5	
Vulcanizate Unaged Properties		
Originals: Cured @ 170°C		
Stress 100%, (psi) MPa (a)	(425)	2.93
Stress 200%, (psi) MPa (a)	(490)	3.39
Stress 300%, (psi) MPa (a)	(575)	3.96
Tensile Strength, (psi) MPa (a)	(2600)	17.91
Ultimate Elongaton, % (a)	(660)	
Hardness Duro A, pts. (b)	71	

OIL WELL CABLE JACKET COMPOUND
Continued

Stress/Strain @ 125°C		
Tensile Strength, (psi) MPa (a)	(440)	3.03
Ultimate Elongation, % (a)	760	
Hardness Duro A, pts. (b)	56	
(a) ASTM D 412		
(b) ASTM D 2240		
Tear, Die C, W/G – ASTM D 624		
R.T., ppi	176	
125°C, ppi	50	
150°C, ppi	34	
Compression Set, Method B, Buttons – ASTM D 395		
70 Hrs. @ 100°C, % Set	43	
70 Hrs. @ 150°C, % Set	80	
Pico Abrasion, 4.5 kgs. 60 RPM, 40-40 Rev. – ASTM D 228		
Specific Gravity	1.391	
Abrasion Loss, Relative Index, %	48	
Permanent Set, 300% Elongation, 10' Hold – ASTM D 412		
% Set, 10' Relax	45	
% Set, 30' Relax	43	
ASTM Brittleness Test, ASTM D 2137		
Tp, °C	-6	
Aged Properties		
Air Age Test Tube; 70 Hrs. @ 125°C – ASTM D 865		
Tensile Strength, (psi) MPa	(2000)	13.79
Tensile Change, %	-23	
Ultimate Elongation, %	590	
Elongation Change, %	-11	
Hardness Duro A, pts.	74	
Hardness Change, pts.	+3	
Weight Change, %	-0.90	

OIL WELL CABLE JACKET COMPOUND Continued

Immersion Properties		
ASTM 3 Oil Immersion, 70 Hrs. @ 125°C – ASTM D 471		
Tensile Strength, (psi) MPa	(1900)	13.10
Tensile Change, %	-27	
Ultimate Elongation, %	610	
Elongation Change, %	-8	
Hardness Duro A, pts.	57	
Hardness Change, pts.	-14	
Volume Change, %	9.0	
Distilled H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2225)	15.34
Tensile Change, %	-14	
Ultimate Elongation, %	600	
Elongation Change, %	-9	
Hardness Duro A, pts.	79	
Hardness Change, pts.	+8	
Weight Change, %	7.4	
Volume Change, %	11.0	
5% KW-44/H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3450)	23.79
Tensile Change, %	+33	
Ultimate Elongation, %	680	
Elongation Change, %	+3	
Hardness Duro A, pts.	73	
Hardness Change, pts.	+2	
Weight Change, %	13	
Volume Change, %	18	
Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(1700)	11.72
Tensile Change, %	-35	
Ultimate Elongation, %	570	
Elongation Change, %	-14	
Hardness Duro A, pts.	44	
Hardness Change, pts.	-27	
Weight Change, %	15.0	
Volume Change, %	22.0	

OIL WELL CABLE JACKET COMPOUND
Continued

5% K-147/Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(1575)	10.86
Tensile Change, %	-39	
Ultimate Elongation, %	640	
Elongation Change, %	-3	
Hardness Duro A, pts.	33	
Hardness Change, pts.	-38	
Weight Change, %	28.0	
Volume Change, %	43.0	

DRILL PIPE WIPER COMPOUND

Zeon

Nipol 1072	100.0	
Zinc Oxide A (Z-CN) D085	5.8	
Spider Sulfur	1.5	
Agerite Resin D	5.0	
Stearic Acid	1.0	
WB-212	2.0	
N-330 HAF	30.0	
Santicizer 711	15.0	
CBTS	0.75	
TETD	1.25	
TMTD	1.25	
Total	**163.55**	
Processing Properties		
Mooney Viscometer, Large Rotor, 125°C – ATM D 1646		
Viscosity, minimum	14.0	
t5, minutes	23.0	
t35, minutes	27.0	
Rheometer, Micro Die, 100° CPM, 1° Arc, 170° C – ASTM D 2084		
ML, lbf. in.	2.6	
MH, lbf. in.	30.5	
ts2, minutes	2.0	
t'90, minutes	8.0	
t'90 x 1.25, minutes	10.0	
Cure Time, minutes	10.0	
Vulcanizate Unaged Properties		
Originals: Cured @ 170°C		
Stress 100%, (psi) MPa (a)	(350)	2.41
Stress 200%, (psi) MPa (a)	(800)	5.52
Stress 300%, (psi) MPa (a)	(1450)	10.0
Tensile Strength, (psi) MPa (a)	(2750)	19.0
Ultimate Elongaton, % (a)	450	
Hardness Duro A, pts. (b)	65	

DRILL PIPE WIPER COMPOUND
Continued

Stress/Strain @ 125°C		
Tensile Strength, (psi) MPa (a)	(710)	5.0
Ultimate Elongation, % (a)	480	
Hardness Duro A, pts. (b)	53	
(a) ASTM D 412		
(b) ASTM D 2240		
Tear, Die C, W/G – ASTM D 624		
R.T., ppi	200	
125°C, ppi	70	
150°C, ppi	56	
Compression Set, Method B, Buttons – ASTM D 395		
70 Hrs. @ 100°C, % Set	37	
70 Hrs. @ 150°C, % Set	74	
Pico Abrasion, 4.5 kgs. 60 RPM, 40-40 Rev. – ASTM D 228		
Specific Gravity	1.124	
Abrasion Loss, Relative Index, %	147	
Permanent Set, 300% Elongation, 10’ Hold – ASTM D 412		
% Set, 10’ Relax	6	
% Set, 30’ Relax	2	
ASTM Brittleness Test, ASTM D 2137		
Tp, °C	-42	
Aged Properties		
Air Age Test Tube; 70 Hrs. @ 125°C – ASTM D 865		
Tensile Strength, (psi) MPa	(2150)	14.82
Tensile Change, %	-22	
Ultimate Elongation, %	200	
Elongation Change, %	-56	
Hardness Duro A, pts.	75	
Hardness Change, pts.	+10	
Weight Change, %	-2.19	

DRILL PIPE WIPER COMPOUND
Continued

ASTM 3 Oil Immersion, 70 Hrs. @ 125°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3560)	24.55
Tensile Change, %	+29	
Ultimate Elongation, %	260	
Elongation Change, %	-42	
Hardness Duro A, pts.	77	
Hardness Change, pts.	+12	
Volume Change, %	-0.11	
Distilled H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2400)	16.55
Tensile Change, %	-13	
Ultimate Elongation, %	250	
Elongation Change, %	-44	
Hardness Duro A, pts.	66	
Hardness Change, pts.	+1	
Weight Change, %	35.0	
Volume Change, %	39.0	
5% KW-44/H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2000)	13.79
Tensile Change, %	-27	
Ultimate Elongation, %	260	
Elongation Change, %	-42	
Hardness Duro A, pts.	58	
Hardness Change, pts.	-7	
Weight Change, %	44	
Volume Change, %	49	
Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2160)	14.89
Tensile Change, %	-21	
Ultimate Elongation, %	280	
Elongation Change, %	-38	
Hardness Duro A, pts.	59	
Hardness Change, pts.	-6	
Weight Change, %	15.0	
Volume Change, %	19.0	

DRILL PIPE WIPER COMPOUND
Continued

5% K-147/Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(1600)	11.03
Tensile Change, %	-42	
Ultimate Elongation, %	270	
Elongation Change, %	-40	
Hardness Duro A, pts.	53	
Hardness Change, pts.	-12	
Weight Change, %	26.0	
Volume Change, %	32.0	

DRILL PIPE PROTECTOR COMPOUND

Zeon

Nipol 1051	100.0	
Zinc Oxide	5.0	
Stearic Acid	1.0	
Spider Sulfur	0.1	
N-326 AHF-LS	20.0	
N-231 ISAF-LM	35.0	
Agerite Resin d	1.0	
Cumar P-10	10.0	
Vultrol	1.0	
TMTD	3.0	
Total	**176.1**	
Processing Properties		
Mooney Viscometer, Large Rotor, 125°C – ASTM D 1646		
Viscosity, minimum	47	
t5, minutes	14.0	
t35, minutes	27.5	
Rheometer, Micro Die, 100° CPM, 1° Arc, 170°C – ASTM D 2084		
ML, lbf. in.	6.5	
MH, lbf. in.	28.0	
ts1, minutes	2.0	
t’90, minutes	7.0	
t’90 X 1.25, minutes	8.8	
Cure Time, minutes	10.0	
Vulcanized Unaged Properties		
Originals: Cured @ 170°C		
Stress 100%, (psi) MPa (a)	(300)	2.07
Stress 200%, (psi) MPa (a)	(550)	3.79
Stress 300%, (psi) MPa (a)	(1025)	7.07
Tensile Strength, (psi) MPa (a)	(3500)	24.13
Ultimate Elongation, % (a)	730	
Hardness Duro A, pts. (b)	70	
Stress/Strain @ 125°C		
Tensile Strength, (psi) MPa (a)	(1440)	9.93
Ultimate Elongation, % (a)	1030	
Hardness Duro A, pts.	53	

DRILL PIPE PROTECTOR COMPOUND
Continued

Tear, Die C, W/G – ASTM D 624		
R.T., ppi	345	
125°C, ppi	215	
150°C, ppi	181	
Compression Set, Method B, Buttons – ASTM D 395		
70 Hrs. @ 100°C, % Set	29	
70 Hrs. @ 150°C, % Set	79	
Pico Abrasion, 4.5 kgs., 60 RPM, 40-40 Rev. – ASTM D 228		
Specific Gravity	1.204	
Abrasion Loss, Relative Index, %	121	
Permanent Set, 300% Elongation, 10’ Hold – ASTM D 412		
% Set, 10’ Relax	11	
% Set, 30’ Relax	8	
ASTM Brittleness Test, ASTM D 2137		
Tp, ° C	-18	
Aged Properties		
Air Age Test Tube; 70 Hrs., @ 125°C – ASTM D 865		
Tensile Strength, (psi) MPa (a)	(3350)	23.10
Tensile Change, %	-4	
Ultimate Elongation, %	420	
Elongation Change, %	-42	
Hardness Duro A, pts.	78	
Hardness Change, pts.	+8	
Weight Change, %	-1.60	
Immersion Properties		
ASTM 3 Oil Immersion, 70 Hrs. @ 125°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3700)	25.51
Tensile Change, %	+6	
Ultimate Elongation, %	620	
Elongation Change, %	-15	
Hardness Duro A, pts.	62	
Hardness Change, pts.	-8	
Volume Change, %	2.2	

**DRILL PIPE PROTECTOR COMPOUND
Continued**

Distilled H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2950)	20.34
Tensile Change, %	-16	
Ultimate Elongation, %	550	
Elongation Change, %	-25	
Hardness Duro A, pts.	67	
Hardness Change, pts.	-3	
Weight Change, %	8.7	
Volume Change, %	11.0	
5% KW-44/H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3400)	23.44
Tensile Change, %	-3	
Ultimate Elongation, %	600	
Elongation Change, %	-18	
Hardness Duro A, pts.	58	
Hardness Change, pts.	-12	
Weight Change, %	20	
Volume Change, %	24	
Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3025)	20.86
Tensile Change, %	-14	
Ultimate Elongation, %	630	
Elongation Change, %	-14	
Hardness Duro A, pts.	47	
Hardness Change, pts.	-23	
Weight Change, %	14.0	
Volume Change, %	19.0	
5% K-147/Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2490)	17.17
Tensile Change, %	-29	
Ultimate Elongation, %	580	
Elongation Change, %	-21	
Hardness Duro A, pts.	47	
Hardness Change, pts.	-23	
Weight Change, %	22.0	
Volume Change, %	30.0	

ANNULAR BLOWOUT PREVENTER COMPOUND
Zeon

Nipol 1051	100.0	
Zinc Oxide XX-78	5.0	
Spider Sulfur	1.5	
Stearic Acid	1.0	
Black Pearls L	15.0	
N231 ISAF-LM	45.0	
Cab-O-Sil MS-7SD	15.0	
Agerite Resin D	3.0	
Antozite 67F	1.0	
Cumar P-25	10.0	
MBTS	1.5	
TETD	0.2	
SI-69	1.0	
Total	**199.2**	
Processing Properties		
Mooney Viscometer, Large Rotor, 125°C – ASTM D 1646		
Viscosity, minimum	87.0	
t5, minutes	9.5	
t35, minutes	12.0	
Rheometer, Micro Die, 100° CPM, 1° Arc, 170°C – ASTM D 2084		
ML, lbf. in.	11.5	
MH, lbf. in.	43.5	
ts1, minutes	1.2	
t’90, minutes	5.3	
t’90 X 1.25, minutes	6.6	
Cure Time, minutes	10.0	
Vulcanized Unaged Properties		
Originals: Cured @ 170°C		
Stress 100%, (psi) MPa (a)	(550)	3.79
Stress 200%, (psi) MPa (a)	(1125)	7.76
Stress 300%, (psi) MPa (a)	(1920)	13.24
Tensile Strength, (psi) MPa (a)	(3250)	22.41
Ultimate Elongation, % (a)	480	
Hardness Duro A, pts. (b)	82	

ANNULAR BLOWOUT PREVENTER COMPOUND
Continued

Stress/Strain @ 125°C		
Tensile Strength, (psi) MPa (a)	(1575)	10.86
Ultimate Elongation, % (a)	820	
Hardness Duro A, pts. (b)	68	
(a) ASTM D 412		
(b) ASTM D 2240		
Tear, Die C, W/G – ASTM D 624		
R.T., ppi	363	
125°C, ppi	295	
150°C, ppi	213	
Compression Set, Method B, Buttons – ASTM D 395		
70 Hrs. @ 100°C, % Set	64	
70 Hrs. @ 150°C, % Set	95	
Pico Abrasion, 4.5 kgs., 60 RPM, 40-40 Rev. – ASTM D 228		
Specific Gravity	1.265	
Abrasion Loss, Relative Index, %	246	
Permanent Set, 300% Elongation, 10’ Hold – ASTM D 412		
% Set, 10’ Relax	12	
% Set, 30’ Relax	10	
ASTM Brittleness Test, ASTM D 2137		
Tp, ° C	-4	
Aged Properties		
Air Age Test Tube; 70 Hrs., @ 125°C – ASTM D 865		
Tensile Strength, (psi) MPa	(2250)	15.51
Tensile Change, %	-31	
Ultimate Elongation, %	150	
Elongation Change, %	-69	
Hardness Duro A, pts.	89	
Hardness Change, pts.	+7	
Weight Change, %	-1.13	

ANNULAR BLOWOUT PREVENTER COMPOUND Continued

Immersion Properties		
ASTM 3 Oil Immersion, 70 Hrs. @ 125°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2750)	18.96
Tensile Change, %	-15	
Ultimate Elongation, %	290	
Elongation Change, %	-40	
Hardness Duro A, pts.	84	
Hardness Change, pts.	+2	
Volume Change, %	1.4	
Distilled H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2850)	19.65
Tensile Change, %	-12	
Ultimate Elongation, %	380	
Elongation Change, %	-21	
Hardness Duro A, pts.	76	
Hardness Change, pts.	-6	
Weight Change, %	9.6	
Volume Change, %	10.0	
5% KW-44/H_2O, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(3200)	22.06
Tensile Change, %	-1	
Ultimate Elongation, %	400	
Elongation Change, %	-17	
Hardness Duro A, pts.	67	
Hardness Change, pts.	-15	
Weight Change, %	20	
Volume Change, %	24	
Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2850)	19.65
Tensile Change, %	-12	
Ultimate Elongation, %	370	
Elongation Change, %	-23	
Hardness Duro A, pts.	62	
Hardness Change, pts.	-20	
Weight Change, %	13.0	
Volume Change, %	17.0	

ANNULAR BLOWOUT PREVENTER COMPOUND
Continued

5% K-147/Diesel Fuel No. 2, 168 Hrs. @ 100°C – ASTM D 471		
Tensile Strength, (psi) MPa	(2525)	17.41
Tensile Change, %	-22	
Ultimate Elongation, %	390	
Elongation Change, %	-19	
Hardness Duro A, pts.	54	
Hardness Change, pts.	-28	
Weight Change, %	24.0	
Volume Change, %	33.0	

BLACK CABLE SHEATH 60 ShA
Enichem

Europrene N OZO 7028		100
ZnO		5
Stearic acid		1
N 762 SRF		25
Calcium carbonate		20
Litharge		5
Cereclor 70		20
Reofos 65		30
Paraffin		3
Antimony oxide		7.5
MBTS		1.5
Eveite D		0.25
TMTD		0.25
Sulphur		1.75
Press cure 10 min at 170°C		
M200	MPa	4.2
T.S.	MPa	15.1
E.B.	%	500
Hardness ShA	points	57
Tear resistance	N/mm	35
Density	gr/cm^3	1.328
Lower Oxygen Index (L.O.I.)	%	28
USA UL 94 Vertical		V°
Ageing in ASTM #2 oil 168h at 90°C		
Δ T.S.		9
Δ E.B.		-30
Δ ShA		4
Δ Volume		-9
Ageing in ASTM #2 oil 24h at 100°C		
Δ T.S.		9
Δ E.B.		-32
Δ ShA		5
Δ Volume		-5
Ageing in Air 168h at 70°C		
Δ T.S.		3
Δ E.B.		-22
Δ ShA		2

BLACK CABLE SHEATH 60 ShA
Continued

Ageing in Air 240h at 70°C	
Δ T.S.	11
Δ E.B.	-20
Δ ShA	3
Ageing in Air 240h at 100°C	
Δ T.S.	-4
Δ E.B.	-64
Δ ShA	9

BLACK CABLE SHEATH 70 ShA
Enichem

Europrene N OZO 7028		100
ZnO		5
Stearic acid		0.8
N 762 SRF		20
N 550 FEF		30
Calcium carbonate		60
Cereclor 70		2
Reofos 65		40
Antimony oxide		10
Flectol H		1.5
Vulkanox 4010NA		1.5
Coumarone resin		5
MBTS		1.6
MBT		1.6
TMTM		0.75
Sulphur		2
Press cure 10 min at 170°C		
M200	MPa	8.3
T.S.	MPa	13.2
E.B.	%	340
Hardness ShA	points	71
Tear resistance	N/mm	46
Density	gr/cm^3	1.46
Lower Oxygen Index (L.O.I.)	%	27.5
Ageing in ASTM #2 oil 168h at 90°C		
Δ T.S.	%	7
Δ E.B.	%	-32
Δ ShA	points	6
Δ Volume	%	-8
Ageing in ASTM #2 oil 24h at 100°C		
Δ T.S.	%	0
Δ E.B.	%	-17
Δ ShA	points	3
Δ Volume	%	-4
Ageing in Air 168h at 70°C		
Δ T.S.	%	-2
Δ E.B.	%	-12
Δ ShA	points	1

BLACK CABLE SHEATH 70 ShA
Continued

Ageing in Air 240h at 70°C		
Δ T.S.	%	-4
Δ E.B.	%	-12
Δ ShA	points	1
Ageing in Air 240h at 100°C		
Δ T.S.	%	3
Δ E.B.	%	-52
Δ ShA	points	7

BLACK CABLE SHEATH 80 ShA
Enichem

Europrene N OZO 7028		100
ZnO		5
Stearic acid		1
N 550 FEF		50
Kaolin		50
Reofos 65		10
DOP		10
Paraffin		2
Antimony oxide		5
Flectol H		1.5
Vulkanox MB		1.5
MBTS		1.3
TMTM		0.2
Sulphur		1.8
Press cure 10 min at 170°C		
M200	MPa	9.8
T.S.	MPa	14.9
E.B.	%	380
Hardness ShA	points	78
Tear resistance	N/mm	55
Density	gr/cm^3	1.422
Lower Oxygen Index (L.O.I.)	%	29
USA UL 94 Vertical		V°
Ageing in ASTM #2 oil 168h at 90°C		
Δ T.S.	%	10
Δ E.B.	%	-45
Δ ShA	points	8
Δ Volume	%	-17
Ageing in ASTM #2 oil 24h at 100°C		
Δ T.S.	%	3
Δ E.B.	%	-5
Δ ShA	points	5
Δ Volume	%	-2
Ageing in Air 168h at 70°C		
Δ T.S.	%	7
Δ E.B.	%	-26
Δ ShA	points	1

BLACK CABLE SHEATH 80 ShA
Continued

Ageing in Air 240h at 70°C		
Δ T.S.	%	5
Δ E.B.	%	-24
Δ ShA	points	5
Ageing in Air 240h at 100°C		
Δ T.S.	%	11
Δ E.B.	%	-66
Δ ShA	points	9

NON-BLACK CABLE SHEATH 70 SHA
Enichem

Europrene N OZO 7028		100
ZnO		5
Stearic acid		0.8
Whitetex		100
Calcium carbonate		20
Cereclor 70		2
Reofos 65		30
Antimony oxide		10
Flectol H		1.5
Vulkanox 4010NA		1
Coumarone resin		5
MBTS		1.6
MBT		1.6
Sulphur		2
Press cure 10 min at 170°C		
M200	MPa	4.4
T.S.	MPa	11
E.B.	%	440
Hardness ShA	points	71
Tear resistance	N/mm	35
Density	gr/cm^3	1.565
Lower Oxygen Index (L.O.I.)	%	30.4
USA UL 94 Vertical		V°
Ageing in ASTM #2 oil 168h at 90°C		
Δ T.S.	%	4
Δ E.B.	%	-25
Δ ShA	points	5
Δ Volume	%	-5
Ageing in ASTM #2 oil 24h at 100°C		
Δ T.S.	%	1
ΔE.B.	%	-11
Δ ShA	points	1
Δ Volume	%	-3
Ageing in Air 168h at 70°C		
Δ T.S.	%	-7
Δ E.B.	%	-11
Δ ShA	points	2

NON-BLACK CABLE SHEATH 70 ShA
Continued

Ageing in Air 240h at 70°C		
Δ T.S.	%	1
Δ E.B.	%	-9
Δ ShA	points	3
Ageing in Air 240h at 100°C		
Δ T.S.	%	-5
Δ E.B.	%	-38
Δ ShA	points	7

CONVEYOR BELT, HIGH ABRASION RESISTANCE
Enichem

Europrene N 3345		85
Europrene Cis		15
N 330 HAF		40
Stearic acid		1
ZnO		5
Sulphur		1.5
MBTS		1.8
DPG		0.5
Aminox		1
Vulkanox MB		1
Aromatic Oil R-17		10
Coumarone 75		5
Press cure 4 min at 153°C		
M300	MPa	6.9
T.S.	MPa	15.7
E.B.	%	550
Hardness ShA	points	60
Tear resistance	N/mm	44
Abrasion resistance DIN		86
Compression set 70h 100°C	%	67

WHITE FOOD BELT COVERS

Goodyear

	1	2	3	4	5
Chemigum NX775	100.00	100.00	100.00	100.00	100.00
OXY221 PVC Resin	0.00	0.00	50.00	50.00	100.00
Hi-Sil 143LD	30.00	30.00	20.00	20.00	20.00
Hi-Sil EP	30.00	30.00	0.00	0.00	0.00
Mistron Vapor	20.00	20.00	80.00	80.00	100.00
Diisodecyl Phthalate	15.00	30.00	20.00	40.00	50.00
Dioctyl Phthalate	15.00	30.00	20.00	40.00	50.00
Vanstay 9100	0.00	0.00	1.50	1.50	2.00
Polygard	0.00	0.00	1.50	1.50	2.00
Calcium Stearate	0.00	0.00	2.00	2.00	4.00
Wingstay L	2.00	2.00	2.00	2.00	2.00
Stearic Acid	1.00	1.00	1.00	1.00	1.00
Wingstack 95	12.00	12.00	12.00	12.00	15.00
Carbowax 3350	1.50	1.50	2.00	2.00	2.25
Vanfre AP-2	2.00	2.00	2.00	2.00	2.00
Kadox 911C ZnO	5.00	5.00	5.00	5.00	5.00
Sulfur, Spider Brand	1.50	1.50	1.50	1.50	1.50
Unads (TMTM)	0.10	0.10	0.10	0.10	0.10
Amax (OBTS)	1.50	1.50	1.50	1.50	1.50
Total	**236.60**	**266.60**	**322.10**	**263.10**	**458.35**
Rheometer, 177C°, 3° Arc, 100 CPM, 12 Min. Motor					
Torque, Min.	4.0	1.5	3.7	1.5	1.3
Torque, Max.	31.4	9.6	17.6	7.0	3.8
TS 2, minutes	3.1	4.3	4.3	5.4	8.2
T’C90, minutes	8.3	8.0	9.4	9.7	10.8
Rheometer, 163C°, 3° Arc, 100 CPM, 60 Min. Motor					
Torque, Min.	4.5	1.7	4.7	2.0	1.7
Torque, Max.	33.2	8.0	24.2	8.8	4.5
TS 2, minutes	5.2	8.0	7.0	10.0	14.0
T’C90, minutes	23.5	16.5	32.0	34.0	32.6
M/L-4 Min. @ 250°F(121°C)	37	15	38	17	21

WHITE FOOD BELT COVERS
Continued

Scorch, M/S 150°F (121°C)					
Minimum	14.0	5.0	14.0	6.0	7.0
T3, minutes	16.0	19.4	14.9	16.8	----
20 Min. Reading	----	----	----	----	10.8
SPECIFIC GRAVITY	1.237	1.196	1.316	1.261	1.271
Original Physical Properties					
Tensile, psi	1977	1059	1879	1091	1003
Elongation, %	440	408	373	380	284
100% Modulus, psi	647	367	1017	574	669
200% Modulus, psi	974	578	1267	754	852
300% Modulus, psi	1310	796	1589	937	1048
Shore A Hardness	82	71	82	71	73
Tear, Die-C, in ppi	196	121	214	140	133
Din Abrasion					
Rel. Vol. Loss(mm^3)	198.2	212.5	186.6	218.4	284.1
Pico Abrasion					
Index, %	36	22	28	21	22
Taber Abrasion, H-18 Abraders/1000 Gms./10000 Cycles					
Gms. Loss	.4420	.3487	.4002	.6833	.6693
Gehman Temp. Torsion (°C)					
T(2)	2	-4	4	2	-4
T(5)	-13	-17	-8	-15	-16
T(10)	-18	-22	-13	-20	-22
T(100)	-32	-38	-26	-34	-38
Brittle Temp.(°C)	-35.5	-45.7	-22.3	-37.9	-34.3
OZONE RESISTANCE, 50 PPHM X 7 DAYS X 40°C, BENT LOOP					
Rating	Broke	Broke	0/0	0/0	0/0

BLACK 90 DURO PEROXIDE CURED, LOW COMPRESSION SET
Goodyear

	1	2	3	4	5
Chemigum NX775	100.00	100.00	100.00	100.00	100.00
N762 Carbon Black	60.00	40.00	0.00	0.00	0.00
N990 Carbon Black	0.00	0.00	60.00	90.00	60.00
Agerite Resin D	1.50	1.50	1.50	1.50	1.50
Stearic Acid	2.00	2.00	2.00	2.00	2.00
Santicizer 261	6.00	6.00	6.00	6.00	6.00
Sunolite 240 Wax	0.50	0.50	0.50	0.50	0.50
Kadox 911C ZnO	5.00	5.00	5.00	5.00	5.00
Perkadox 14/40	3.75	3.75	3.75	3.75	3.75
Saret 500	6.00	6.00	6.00	6.00	15.00
Total	**184.75**	**164.75**	**184.75**	**214.75**	**193.75**
Rheometer, 325°F, 3° Arc, 100 CPM, 60 Min. Motor					
Torque, Min.	6.4	5.6	5.6	6.0	4.0
Torque, Max.	136.0	116.0	119.6	138.0	118.4
TS 2, minutes	1.8	1.7	1.7	1.5	2.0
T'C 90, minutes	15.8	19.4	16.4	16.7	17.0
T'C 95, minutes	22.0	18.3	20.2	21.0	23.0
Rheometer, 350°F, 3° Arc, 100 CPM, 60 Min. Motor					
Torque, Min.	6.5	5.0	5.0	6.5	5.0
Torque, Max.	149.0	131.0	132.0	149.5	123.5
TS 2, minutes	0.8	1.1	0.8	0.8	1.1
T'C 90, minutes	6.9	7.1	7.6	7.3	6.2
T'C 95, minutes	8.5	9.0	9.6	9.4	7.9
M/L-4 Min. @ 212°F(100°C)					
	44	34	36	46	26
Scorch, M/S @ 250°F(121°C)					
Minimum	16	12	13	16	9
20 Min. Reading	16.9	12.8	13.3	16.4	9.6
Scorch, M/L @ 250°F(121°C)					
Minimum	30	23	23	30	17
20 Min. Reading	19.7	24.8	24.6	32.4	18.1
T3, minutes	19.5	----	----	----	----
SPECIFIC GRAVITY	1.220	1.175	1.218	1.275	1.220

BLACK 90 DURO PEROXIDE CURED, LOW COMPRESSION SET Continued

Original Physical Properties, 25' @ 325°F(163°C)					
Tensile, psi	4075	3750	2750	2725	3200
Elongation, %	120	160	160	140	120
Shore A Hardness	91	89	88	92	92
Shore D Hardness	47	41	39	47	48
Tear @ 73°F(23°C), in ppi					
Die (B)	208	166	185	205	175
Die (C)	266	240	227	224	194
Din Abrasion					
Rel. Vol. Loss (mm^3)	159.3	129.0	86.5	239.0	223.6
Pico Abrasion					
Index, %	419	399	271	196	178
NBS Abrasion					
Index, %	150	130	101	107	89
Compression Set (B)					
32Hrs./257°F(125°C)%	11.2	11.0	11.8	11.5	10.7
70 Hrs./257°F(125°C)%	22.9	21.3	21.4	21.1	18.5
Air Oven Aging – 70 Hrs. @ 257°C(125°C)					
Tensile, psi	3950	3325	3600	3375	3675
% Change	-3	-11	+31	+24	+15
Elongation, %	60	100	70	70	60
% Change	-50	-37	-56	-50	-50
Shore A Hardness	64	54	55	64	64
Points Change	+17	+15	+16	+17	+16
Fluid Aging – 70 Hrs. @ 257°C(125°C), ASTM No. 3 Oil					
Tensile, psi	3910	3800	3525	3650	3750
% Change	-4	+1	+28	+34	+17
Elongation, %	85	105	128	104	80
% Change	-29	-34	-20	-26	-33
Shore D Hardness	47	43	41	48	49
Points Change	0	+2	+3	+1	+1
Shore A Hardness	91	91	91	93	93
Volume Swell, %	+5.7	+5.9	+5.9	+4.9	+4.6

HIGH HARDNESS COMPOUND FOR COMPRESSION MOULDING
Enichem

Recipe		
Europrene N 3945		100
ZnO		5
Stearic acid		1
N 772 SRF		70
N 330 HAF		40
DOP		10
Coumarone resin		5
MBTS		1.5
TMTM		0.3
Sulphur		2.5
Press cure 5 min at 160°C		
T.S.	MPa	20.1
E.B.	%	140
Hardness ShA	points	88
Tear resistance	N/mm	46

85 SHORE A ULTRA LOW TEMPERATURE RESISTANT
Zeon

Zetpol 4110	100.0
N-550 (FEF)	125.0
Kadox (ZnO)	3.0
Maglite D	5.0
Naugard 445	2.0
Vanox ZMTI	1.0
PlastHall 203	15.0
PlastHall 207	15.0
HVA-2	2.5
Vul-Cup 40KE	6.5
Total	**275.0**
Processing Properties	
Mooney Viscosity	
(1+4) @ 100°C (212°F)	162.2
Mooney Scorch, MS (1+30) @ 125°C(257°F)	
Viscosity, min.	118.6
t5, min.	3.9
t35, min.	7.2
ODR, Microdie, 100 CPM, 3° Arc @ 170°C(338°F)	
MI, dN-m	16.6
MI, lbf.in.	18.7
Mh, dN-m	83.3
Mh, lbf.in.	94.1
ts2, min.	1.0
t90, min.	9.4
Vulcanizate Properties	
Originals, Cured @ 170°C(338°F), 12 minutes	
Hardness, Shore A, pts.	85.0
Modulus @ 100%, MPa (psi)	11.4(1652)
Tensile, MPa (psi)	12.2(1769)
Elongation, %	107
Compression Set, Method B	
70 Hr. @ 150°C(302°F), %	53.2

85 SHORE A ULTRA LOW TEMPERATURE RESISTANT Continued

Aged Properties	
Aged in Air Oven 70 Hr. @ 150°C(302°F)	
Hardness, A, pts.	99
Hardness, change, pts.	14
Tensile, psi	2226
Tensile, change, %	26
Elongation, %	87
Elongation, change, %	-19
Aged in #3 Oil, 70 Hr. @ 150°C(302°F)	
Hardness, A, pts.	67
Hardness, change, pts.	-18
Tensile, psi	1948
Tensile, change, %	10
Elongation, %	115
Elongation, change, %	7
Volume, %	23.9

80 DUROMETER WHITE RECIPES FOR ABRASION SERVICE
Goodyear

	1	2	3	4
Chemigum NX775	85.00	85.00	85.00	85.00
Budene 1207	15.00	15.00	15.00	15.00
Hi-Sil 243LD	20.00	20.00	20.00	20.00
Rutile Titanium Dioxide	20.00	20.00	20.00	20.00
Mistron Vapor	10.00	10.00	10.00	10.00
Wingstay L	2.00	2.00	2.00	2.00
Stearic Acid	2.00	2.00	2.00	2.00
SI-69	4.00	4.00	4.00	4.00
Sunolite 240 Wax	1.00	1.00	1.00	1.00
Diisodecyl Phthalate	10.00	20.00	25.00	30.00
Pasco 558T Zinc Oxide	7.00	7.00	7.00	7.00
Magnesium Oxide	5.00	5.00	5.00	5.00
Spider Sulfur	2.00	2.00	2.00	2.00
Unads (TMTM)	1.00	1.00	1.00	1.00
Santogard PVI	0.50	0.50	0.50	0.50
Total	**184.50**	**194.50**	**199.50**	**204.50**
Rheometer, 163°C (325°F), 3° Arc, 100 CPM, 60 Min. Motor				
Torque, Min.	9.0	6.0	5.0	4.0
Torque, Max.	73.4	59.0	51.0	44.0
TS 2, minutes	1.6	2.0	2.5	3.5
T’C80, minutes	7.2	7.8	8.3	9.2
T’C90, minutes	9.5	10.3	10.8	11
Scorch, M/S @ 250°F(121°C)				
Minimum	18	12	10	8
T5, minutes	10.0	11.8	14.4	----
20 Min. Reading	----	----	----	12.9
Specific Gravity	1.269	1.252	1.243	1.329
Original Physical Properties - Cured 30’ @ 325°F(163°C)				
Tensile, psi	2625	1975	2325	1925
Elongation, %	270	250	320	280
300% Modulus, psi	----	----	2225	----
Shore A Hardness	83	80	78	76

80 DUROMETER WHITE RECIPES FOR ABRASION SERVICE Continued

Air Oven Aging - 70 Hrs. @ 212°F(100°C)				
Tensile, psi	3025	2750	2300	2150
% Change	+15	+39	-1	+12
Elongation, %	230	260	230	270
% Change	-15	+4	-28	-4
Shore A Hardness	86	83	82	80
Points Change	+3	+3	+4	+4
Air Oven Aging - 166 Hrs. @ 212°F(100°C)				
Tensile, psi	3200	2650	2400	2125
% Change	+22	+34	+3	+10
Elongation, %	200	210	220	230
% Change	-26	-16	-31	-18
Shore A Hardness	87	85	84	82
Points Change	+4	+5	+6	+6
Tear, Die C, in ppi				
73°F(23°C)	192	183	169	158
212°F(100°C)	91	75	74	73
250°F(121°C)	80	64	79	75
Compression Set (B)				
22 Hrs./212°F(100°C),%	34.8	36.3	31.8	30.2
Pico Abrasion				
Index, %	252	202	164	124

DUROMETER 77 COMPOUND FOR TEAR STRENGTH
PPG

NBR 685B		100.0
Hi-Sil 190G		45.0
DOP		10.0
25C Resin DLC		10.0
TMQ		1.0
Zinc Oxide		1.0
Sulfur		1.5
HMT		2.0
TBBS		2.0
DPTH		1.0
DPG		1.5
Specific Gravity		1.19
Cure Rate, 150C, MDR T50		4.5
Mooney Scorch, 121C, T5		17
Mooney Viscosity, ML100		79
Cure: 10’ & 20’/150C		
Durometer	at 23C - 77	at 100C - 71
	Original	Aged 700 hours, 115C
Durometer	75	90
M20, Mpa	1.1	
M300	4.0	
Tensile	29	14
Elongation, %	770	65
MG Trouser Tar, kN/m		40
PICO Abrasion Index		83
Compression Set, 70 hours, 100C, %		100

DUROMETER 76 COMPOUND FOR ABRASION RESISTANCE
PPG

NBR 685B			100.0
Ciptane I			50.0
DOS			10.0
CI 25°C Resin DLC			10.0
TMQ			1.0
Zinc Oxide			1.0
Sulfur			0.75
TBBS			2.0
DPTH			2.0
HMT			1.0
Specific Gravity			1.20
Cure Rate 150C, T90 minutes			4.2
Mooney Scorch 130C, T5 minutes			7
Viscosity, ML100			62
Durometer: at 23C			76
at 100C			72
Cure: 8'/150C	Original	Aged 70 hrs 140C	Aged 700 hrs. 115C
Durometer	76	86	90
M300, MPa	12.6	---	---
Tensile	26	12	16
Elongation, %	490	135	145
MG Trouser Tear, kN/m			11
Die C Tear, kN/m			
PICO Abrasion Index			96
Compression Set, 70 hrs 100C			74
Pendulum Rebound Z, at 23C			30%
at 100C			58%

BLACK 65 DUROMETER, GENERAL PURPOSE ABRASION SERVICE
Goodyear

Chemigum NX775	100.00
N-660 Carbon Black	20.00
Santicizer 261	10.00
Cumar MH 2-1/2	5.00
Wingstay L	2.00
Stearic Acid	1.00
Kadox 911 Zinc Oxide	6.00
Unads	1.40
Sulfur, Spider Brand	0.75
Wingstay 100	1.00
Total	**147.15**
Rheometer, 325°F(163°C), 3° Arc, 100 CPM, 60 Min. Motor	
Torque, Min.	4.0
Torque, Max.	40.4
TS 2, minutes	7.0
T'C 90, minutes	25.5
T'C 95, minutes	33.5
Specific Gravity	1.101
Original Physical Properties, Cured 325°F (163°C)	
Tensile, psi	3400
Elongation, %	640
300% Modulus, psi	650
Hardness, Shore A	65
Compression Set, Method B	
22 Hrs. @ 212°F(100°C), %	39.4
70 Hrs. @ 212°F(100°C), %	50.9
Pico Abrasion Index	
Index, %	127

LOW HARDNESS COMPOUNDS

Enichem

			1	**2**
Europrene N OZO 7033			100	100
ZnO			5	5
Stearic acid			1	1
N 550 FEF			15	30
Calcium carbonate			20	20
DOP			75	40
Plasticizer SC			25	20
Factis NQ			40	30
Anox HB			1	1
MBTS			1.5	1.5
TMTM			0.5	0.3
Sulphur			1.5	1.5
Press cure at 150°C for:				
M300	7’	MPa	1.8	3.9
	15’	MPa	1.9	4.1
	30’	MPa	2.5	5.1
T.S.	7’	MPa	3.2	6.0
	15’	MPa	3.2	6.2
	30’	MPa	3.5	6.5
E.B.	7’	%	610	565
	15’	%	545	530
	30’	%	470	445
Hardness ShA	7’	points	26	43
	15’	points	27	44
	30’	points	29	46

DIESEL FUEL PUMP MEMBRANE
Enichem

		1	2
Europrene N 3945		75	100
Europrene N 3345		25	-
ZnO		5	5
Stearic acid		1	1
N 762 SRF		65	65
N 990 MT		15	15
DBP		3	3
MBTS		2.5	2.5
TMTD		1.5	1.5
Sulphur		0.4	0.4
Press cure 8 min at 170°C			
Hardness ShA	points	70	68
Density	gr/cm^3	1.29	1.25
Ageing in ASTM #3 oil 96h at 100°C			
Δ Volume		8	3
Ageing in Isooctane 96h at 23°C			
Δ Volume		15	-2

FUEL PUMP MEMBRANE
Enichem

Europrene N 4560	100
ZnO	5
Stearic acid	1
Ultrasil VN3	25
TEA	0.75
Zeolex 25	60
DEG	3.5
Titanium oxide	5
Hycar 1312	10
Paraplex 660	10
Coumarone resin	7
MBTS	1.7
TMTM	0.8
Eveite D	0.7
Sulphur	2.5

Curing conditions	
Time	6’
Temp.	150°C

Processing conditions
MEK Solution (30% solid) of the compound is spreaded on both sides of a phenolic resin pretreated nylon fabric.

SHOCK ABSORBER SPECIFICATION
Uniroyal

Paracril® BJLT-M50		100.0
Zinc Oxide		5.0
Aminox®		2.0
Stearic Acid		1.0
FEF (N-550) Black		65.0
Plasticizer SC		10.0
Cumar P-10		10.0
Naugex® SD-1		1.25
Delac® S		2.0
Tuex®		1.25
Total		**197.5**
Mooney Viscosity		
ML –4 @ 100°C(212°F)		46
		Specification
Unaged Physical Properties		
Press Cured 10 minutes @ 160°C(320°F)		
100% Modulus, Mpa (psi)	3.0(430)	----
Tensile Strength, MPa (psi)	15.6(2550)	10.3 Min. (1500Min.)
Elongation, %	520	250 Min.
Hardness, Shore A	67	70±5
Aged 70 Hours @ 121°C(250°F) in Air		
Tensile Strength, % Change	Nil	-20 Max.
Elongation, % Change	-46	-50 Max.
Hardness Change, Points	+15	+15 Max.
Aged 70 Hours @ 149°C(300°F) in ASTM Oil #3		
Tensile Strength, % Change	-15	
Elongation, % Change	-35	
Hardness Change, Points	-5	
Volume Change, %	+2.7	
Compression Set, Aged 70 Hours @ 121°C(250°F), Method B		
25% Deflection, % Set	*25.0	30.0 Max.
Bureau of Standards Abrasion Index	**242	

* Cured 45 Minutes @ 160°C(320°F)
**Cured 20 Minutes @ 160°C(320°F)

AIR SPRINGS FOR HIGHER TEMPERATURE APPLICATIONS
Zeon

	1	2
Zetpol 2010	100.0	----
Zetpol 2020	----	75.0
ZSC-2295	----	25.0
N-550	15.0	5.0
Paraplex G-31	10.0	10.0
Zinc Oxide	5.0	----
Maglite D	7.5	----
Naugard 445	1.5	1.5
Vanox ZMTI	1.0	----
SR-206	4.0	----
Di-Cup 40KE	8.0	6.5
Total	**152.0**	**123.0**
Processing Properties		
Mooney Viscosity		
(1+4) @ 100°C(212°F)	54.7	48.2
Mooney Scorch, MS (1+30) @ 125°C(257°F)		
Viscosity, min.	30.3	27.1
t5, min.	9.6	8.2
t35, min.	29.9	27.8
ODR, Microdie, 100 CPM, 3° Arc @ 170°C(338°F)		
MI, dN-m	11.7	11.5
MI, lbf.in.	10.4	10.2
Mh, dN-m	62.9	81.3
Mh, lbf.in.	55.7	72.0
ts2, min.	1.5	0.9
t90, min.	9.2	7.2
MDR, 0.5° Arc @ 170°C(338°F)		
MI, dN-m	0.6	0.5
MI, lbf.in.	0.7	0.6
Mh, dN-m	7.3	9.0
Mh, lbf.in.	8.3	10.2
ts2, min.	----	0.8
t90, min.	10.6	5.7

AIR SPRINGS FOR HIGHER TEMPERATURE APPLICATIONS Continued

Vulcanizate Properties		
Originals, Cured @ 170°C, 15 min.		
Hardness, Shore A, pts	53	56
Modulus @ 100%, MPa (psi)	1.2(172)	1.8(257)
Modulus @ 200%, MPa (psi)	2.1(306)	3.8(553)
Modulus @ 300%, MPa (psi)	4.4(635)	7.8(1133)
Tensile, MPa (psi)	22.3(3238)	29.3(4245)
Elongation, %	604	522
Tear, Die C, W/G, pli	169	213
23°C, kN/m	29.6	37.3
Compression Set, Method B		
70 Hr. @ 150°C, %	37.5	52.1
Aged Properties		
Aged in Air Oven 168 Hrs. @ 125°C(257°F)		
Hardness, A, pts.	61	64
Hardness, change, %	8	8
Modulus @ 100%, psi	220	308
Modulus @ 100%, change, %	28	20
Tensile, psi	3721	4890
Tensile, change, %	15	15
Elongation, %	621	521
Elongation, change, %	3	0
Aged in Air Oven 168 Hrs. @ 135°C(275°F)		
Hardness, A, pts.	61	65
Hardness, change, %	8	9
Modulus @ 100%, psi	249	330
Modulus @ 100%, change, %	45	28
Tensile, psi	4096	3650
Tensile, change, %	26	-14
Elongation, %	587	449
Elongation, change, %	-3	-14

AIR SPRINGS FOR HIGHER TEMPERATURE APPLICATIONS Continued

Aged in Air Oven 168 Hrs. @ 150°C(302°F)		
Hardness, A, pts.	63	65
Hardness, change, %	10	9
Modulus @ 100%, psi	294	374
Modulus @ 100%, change, %	71	46
Tensile, psi	3466	3082
Tensile, change, %	7	-27
Elongation, %	579	418
Elongation, change, %	-4	-20
Adhesion Properties		
Adhered to: Neoprene coated fabric		
23°C, pli	44.2	31.1
135°C, pli	3.4	4.4
Adhered to: Un-coated fabric		
23°C, pli	31.5	15.3
135°C, pli	3.7	5.4

CONDUCTIVE EXTRUSION COMPOUND
DSM

Nysnyblak DN120	150.0
N-330 Black	20.0
N-787 Black	68.0
Zinc Oxide	5.0
Stearic Acid	1.0
AGERITE RESIN D	1.5
DOP	50.0
Sulfur	0.5
TMTD	1.5
DTDM	2.0
TMTD	2.0
OBTS	1.5
Total Parts	303.0
Physical Properties	
Compound Viscosity, ML (1+4) 100°C	58
Mooney Scorch @ 132°C	
Min. to 5 Pt. Rise	6.8
Minimum Reading	29
Press Cure @ 162°C, 15 min. cure	
Tensile, MPa	12.76
Elongation, %	170
100% Modulus, MPa	5.86
Hardness, Shore A	79
Compression Set	
70 Hrs. @ 125°C, 25 min. cure	39.4
After Immersion in ASTM Fuel B	
70 Hrs. @ 23°C, 15 min. cure	
Tensile, % Change	-31
Elongation, % Change	-18
Hardness, Pts. Change	-4
Volume Change, %	+3
After Immersion in ASTM Fuel C	
70 Hrs. @ 23°C, 15 min. cure	
Tensile, % Change	-41
Elongation, % Change	-24
Hardness, Pts. Change	+6
Volume Change, %	+8.9

FLOORING
Enichem

Europrene N OZO 7033/60		100
ZnO		5
Stearic acid		1
Ultrasil VN3		50
Silteg AS-7		15
SI 69		1.5
Calcium stearate		1.5
Vanox 2246		1.5
DOP		15
Carbowax 4000		2
MBT		1
TMTM		1
Sulphur		1.5
Mooney Compound (1+4) 100°C		116
Press cure 15 min at 160°C		
T.S.	MPa	15
E.B.	%	450
Hardness ShA	points	80
Tear resistance	N/mm	40
Abrasion resistance (cm^3/40m)		210
Compression set 70h 100°C	%	40

LOW TEMPERATURE RESISTANT MEMBRANE
Enichem

Europrene N 1945 GRN		100
ZnO		5
Stearic acid		1
N 330 HAF		30
Vulkanol 85		10
CBS		3
TMTD		3
Flexamine		1.5
Riowax 721		1
Sulphur		0.3
Press cure 12 min at 155°C		
M300	MPa	55
T.S.	MPa	12
E.B.	%	500
Hardness ShA	points	47
Compression set 22h 100°C	%	16
Brittle point	°C	-56

TRANSFORMER OIL RESISTANCE

Enichem

Europrene N 2845		100
ZnO		5
Stearic acid		1
N 772 SRF		50
Vulkanol 88		10
Vulkanox HS		1.5
MBTS		1.5
TMTM		1.5
Sulphur		1.5
Press cure 10 min at 160°C		
M20	MPa	6.8
T.S.	MPa	10.2
E.B.	%	290
Hardness ShA	points	63
Compression set 70h 100°C	%	18
Ageing in Salamander oil 70h at 100°C		
Δ T.S.	%	0
Δ E.B.	%	-17
Δ ShA	points	-2
ΔVolume	%	4

MILK INFLATORS

Enichem

Europrene N 3380		60
Europrene 1502		40
Stearic acid		1
Regal 300		30
N 772 SRF		20
DOP		45
Antilux 654		2
BLE 25		1
Sulphur		0.25
Vulkanox MOZ		1.5
Fads powder		1.5
ZnO		5
Press cure 7 min at 165°C		
M100	MPa	0.8
M200	MPa	1.8
T.S.	MPa	10.2
E.B.	%	700
Hardness ShA	points	41
DeMattia test	cycles	>300000
Ageing in Ozone 72h, 20%, 50 pphm		Pass

MILK INFLATORS (BGA)

Enichem

Europrene N 2845 GRN		100
ZnO		3
Stearic acid		0.8
Vulcan P		25
Durex O		20
Antiox 2246		1
Vulkanox 4020		1.5
DOA		15
Vulkanol FH		2
DOTG		1
TMTD		1
Sulphur		1
Press cure 5 min at 160°C		
M200	MPa	3.8
T.S.	MPa	17.8
E.B.	%	630
Hardness ShA	points	50
Tear resistance	N/mm	43

NON-BLACK MILKING MACHINE INFLATIONS
Uniroyal

	1	2	3
Paracril® BJLT M50	100.00	----	----
Paracril®OZO M50	----	75.00	100.00
Synpol 1502	----	25.00	----
Spider Sulfur	1.50	1.50	1.50
Stearic Acid	1.00	1.00	1.00
Zinc Oxide	5.00	5.00	5.00
Naugawhite® Powder	1.00	1.00	1.00
Super Multifex	50.00	50.00	50.00
Hi-Sil 233	10.00	10.00	----
Dibutyl Phthalate	12.50	12.50	12.50
Dioctyl Phthalate	12.50	12.50	12.50
Dioctyl Adipate	10.00	10.00	10.00
MBTS	1.00	1.00	1.00
MONEX®	0.25	0.25	0.25
DPG	0.25	0.25	0.25
Unaged Physical Properties, Cured 10 minutes @ 163°C(325°F)			
100% Modulus, MPa (psi)	0.8(110)	1.2(170)	1.2(180)
300% Modulus, MPa (psi)	1.3(190)	2.4(350)	2.5(360)
Tensile Strength, MPa (psi)	10.4(1510)	9.3(1350)	9.9(1430)
Elongation, %	820	650	610
Hardness, Shore A	42	45	47
Mooney Viscosity			
ML-4 @ 100°C(212°F)	20	20	20
Mooney Scorch, MS @ 121°C(250°F)			
Scorch Time, 3 pt. Rise (min.)	22.0	17.5	9.5
Cure Rate, 23 – 3 (min.)	2.3	1.8	1.0
Brittle Point, °C (°F)	-42(-44)	-50(-58)	-42(-44)
Aging in Butter Oil, 70 Hours @ 70°C(158°F)			
Volume Change	-14.0	+8.3	-12.5

TORSIONAL VIBRATION DAMPER

Enichem

Europrene N 2845 GRN		100
ZnO		3
Stearic acid		1
Flectol H		1
Vulkanox 4010 NA		2
Irganox 1425		2
Vulkanox MB2		1
Calcium carbonate		16
N 550 FEF		30
N 762 SRF		40
Struktol WB 300		4
DOP		8
Riowax 721		2
TMTD		1.5
OTOS (Curerite 18)		2.5
CBS		1
Sulphur		0.4
Press cure 10 min at 180°C		
M100	MPa	2.8
M300	MPa	10.7
T.S.	MPa	13.8
E.B.	%	400
Hardness ShA	points	65
Rebound	%	35
Tear resistance	N/mm	39
Compression set 22h 100°C	%	16
Brittle point	°C	-37
TR 10	°C	-33
Ageing in Air 168h at 100°C		
Δ M100	%	15
Δ T.S.	%	7
Δ E.B.	%	-14
Δ ShA	points	-2
Ageing in Air 1000h at 100°C		
Δ T.S.	%	3
Δ E.B.	%	-63
Δ ShA	poitns	22

INJECTION MOLDED COMPOUND
Goodyear

Chemigum N685B	100.00
N0774 (SRF-NS) Carbon Black	60.00
Zinc Oxide	4.00
Wingstay 100	2.00
Paraplex G-25	5.00
TP 95 Plasticizer	7.00
Stearic Acid	0.50
Methyl Tuads	2.00
Amax	2.00
Sulfur, Spider Brand	0.40
Total	**182.90**
Original Physical Properties	
Optimum Cure	14/320°F
Tensile, psi	2323
Elongation, %	433
100% Modulus, psi	468
Shore A Hardness	65
Compression Set (B), 70 Hrs @ 212°F, %	10.8
Fluid Aging – ASTM #3 Oil, 70 Hrs. @ 250°F	
Percent Elongation, % Change	-4
Shore A Hardness, Points Change	0
% Volume Change	+7.8
Fluid Aging – Fuel B, 70 Hrs. @ 73°F	
Percent Elongation, % Change	-40
Shore A Hardness, Points Change	-10
% Volume Change	+28
Low Temperature Brittleness	-38.5

BLACK PEROXIDE CURED, FOR ADHESION TO PRIMED METAL

Goodyear

	1	2	3
Chemigum NX775	100.00	10.00	100.00
N-660 Carbon Black	20.00	20.00	16.00
Dioctyl Phthalate	30.00	20.00	12.00
Stearic Acid	2.00	2.00	2.00
Wingstay 29	1.00	1.00	1.00
Pasco 558T ZnO	5.00	5.00	5.00
Santocure (CBTS)	1.00	1.00	1.00
Spider Sulfur	0.25	0.25	0.25
Di-Cup 40C	4.00	4.00	4.00
Saret 515	1.00	1.00	1.00
Total	**164.25**	**154.25**	**142.25**
Rheometer, 325°F, 3° Arc, 100 CPM, 60 Min. Motor			
Torque, Min.	2.5	4.0	5.5
Torque, Max.	57.0	67.0	74.5
TS 2, minutes	4.1	3.8	3.5
T'C90, minutes	25.0	25.5	24.5
T'C95, minutes	32.0	31.5	30.0
Rheometer, 360°F, 3° Arc, 100 CPM, 60 Min. Motor			
Torque, Min.	4.0	4.5	6.0
Torque, Max.	45.5	53.0	59.0
TS 2, minutes	1.6	1.7	1.8
T'C90, minutes	7.0	7.0	6.5
T'C95, minutes	10.0	9.5	9.5
Scorch, MS/250°F			
Minimum	5.0	7.0	9.0
T5, minutes	0.0	0.0	0.0
30 Min. Reading	5.8	8.0	10.1
Specific Gravity	1.093	1.098	1.097
Original Physical Properties, 20' @ 325°F			
Tensile, psi	1550	2075	2400
Elongation, %	550	510	500
300% Modulus, psi	500	675	800
Shore A Hardness	49	54	60

DUROMETER 68 COMPOUND FOR BRASS ADHESION
PPG

NBR 683B		100.0
Hi-Sil 532EP		60.0
DOP		12.0
25C CI Resin		5.0
TMQ		1.0
ODPA		1.0
Stearic Acid		2.0
R-F Resin		3.0
Magnesia		1.0
Zinc Oxide		5.0
Sulfur		2.0
DPTH		0.5
MOR		1.5
HMMM964		3.0
Specific Gravity		1.22
Cure Rate MDR 150C, T50 minutes		8.6
T90 minutes		22
Mooney Scorch 121C, T5 minutes		30+
Mooney Viscosity, ML100		28
Stress/Strain	Original	Aged 700 hrs. @ 110C
Durometer 23C	68	94
100C	62	
M300, MPa	11	
Tensile	20	9.4
Elongation, %	505	15
Adhesion to Brass Wire (6+3), N/25mm		320(72 lbs./in)
Compression Set, 70 hrs. @ 100C		82%
Goodrich Flexometer, 100C; 22.5%; 1 MPa		
Dynamic Compression, %		5.3
Dynamic Drift, %		19
Permanent Set, %		23
Heat Build-Up, °C		42
Pendulum Rebound (Z), % at 23C		29
at 100C		55

HIGH TEMPERATURE SERVICE

Goodyear

	1	2	3	4
Chemigum NX775	100.00	100.00	100.00	100.00
N-660 Carbon Black	20.00	20.00	0.00	40.00
Hi-Sil 233	0.00	0.00	20.00	0.00
DSC-18	0.00	0.00	0.40	0.00
Agerite Resin D	0.00	0.00	0.00	3.00
Wingstay 29	3.00	3.00	3.00	0.00
Stearic Acid	1.00	1.00	1.00	1.00
Plasticizer TP-759	20.00	20.00	3.00	3.00
Kadox 911C ZnO	5.00	5.00	5.00	5.00
Unads (TMTM)	0.00	2.50	0.00	0.00
Methyl Tuads (TMTD)	0.00	0.25	0.00	0.00
Sulfur, Spider Brand	0.00	1.50	0.00	0.00
Luperco 101XL	4.00	0.00	4.00	4.00
Total	**153.00**	**153.25**	**136.40**	**156.00**
Rheometer, 325°F, 3° Arc, 100 CPM, 12 Min. Motor				
Torque, Min.	6.0	6.0	12.0	12.0
Torque, Max.	80.0	74.6	104.0	102.0
TS 2, minutes	2.0	2.5	2.0	2.0
T’C 90, minutes	26.5	7.3	20.0	25.5
T’C 95, minutes	34.0	10.5	25.0	32.0
SPECIFIC GRAVITY	1.117	1.107	1.137	1.179
Original Physical Properties, Cured 40’ @ 325°F(163°C)				
Tensile, psi	2200	2200	3150	4045
Elongation, %	345	470	295	300
100% Modulus, psi	250	240	700	1150
Shore A Hardness	70	64	82	86
Compression Set, Method B - %				
70 Hrs. @ 212°F(100°C)	12.8	17.0	18.3	21.1
70 Hrs. @ 250°F(121°C)	21.8	29.4	23.9	31.2
70 Hrs. @ 300°F(149°C)	54.9	89.1	55.6	65.4
Pico Abrasion				
Index, %	126	114	404	921

HIGH TEMPERATURE SERVICE
Continued

Tear, ,Die C, in ppi				
73°F(23°C)	149	165	232	270
250°F(121°C)	31	32	102	135
300°F(149°C)	28	25	61	105
Aged Properties, Circ. Air Oven – 70 Hrs. @ 212°F(100°C)				
Tensile, psi	2600	2650	3625	4175
% Change	+18	+20	+15	+3
Elongation, %	285	405	250	210
% Change	-17	-14	-15	-30
Shore A Hardness	79	72	87	91
Points Change	+9	+8	+5	+5
Aged Properties, Circ. Air Oven – 70 Hrs. @ 250°F(121°C)				
Tensile, psi	2415	2550	3550	4050
% Change	+10	+16	+13	0
Elongation, %	210	360	185	135
% Change	-39	-23	-37	-55
Shore A Hardness	84	74	90	93
Points Change	+14	+10	+8	+7

HIGH TEMPERATURE SERVICE

Goodyear

	5	6	7	8
Chemigum NX775	100.00	100.00	100.00	100.00
N-660 Carbon Black	40.00	40.00	20.00	20.00
Hi-Sil 233	0.00	0.00	0.00	0.00
DSC-18	0.00	0.00	0.00	0.00
Agerite Resin D	0.00	0.00	0.00	0.00
Wingstay 29	3.00	3.00	3.00	3.00
Stearic Acid	1.00	1.00	1.00	1.00
Plasticizer TP-759	3.00	3.00	3.00	3.00
Kadox 911C ZnO	5.00	5.00	5.00	5.00
Unads (TMTM)	0.00	2.50	0.00	2.50
Methyl Tuads (TMTD)	0.00	0.25	0.00	0.25
Sulfur, Spider Brand	0.00	1.50	0.00	1.50
Luperco 101XL	4.00	0.00	4.00	0.00
Total	**156.00**	**156.25**	**136.00**	**136.25**
Rheometer, 325°F, 3° Arc, 100 CPM, 12 Min. Motor				
Torque, Min.	12.4	11.2	10.0	10.0
Torque, Max.	113.6	115.6	96.0	96.4
TS 2, minutes	2.3	4.0	2.5	4.0
T'C 90, minutes	26.0	8.3	27.0	8.5
T'C 95, minutes	35.5	13.0	34.0	13.0
SPECIFIC GRAVITY	1.180	1.171	1.123	1.114
Original Physical Properties, Cured 40' @ 325°F(163°C)				
Tensile, psi	4145	3800	3600	3650
Elongation, %	270	350	320	410
100% Modulus, psi	1100	850	645	400
Shore A Hardness	86	83	82	76
Compression Set, Method B - %				
70 Hrs. @ 212°F(100°C)	17.1	17.3	15.4	17.6
70 Hrs. @ 250°F(121°C)	25.7	28.9	23.2	26.9
70 Hrs. @ 300°F(149°C)	61.4	87.2	52.3	84.5
Pico Abrasion				
Index, %	872	866	478	373

HIGH TEMPERATURE SERVICE
Continued

Tear, ,Die C, in ppi				
73°F(23°C)	242	287	229	239
250°F(121°C)	115	138	76	105
300°F(149°C)	70	121	74	81
Aged Properties, Circ. Air Oven – 70 Hrs. @ 212°F(100°C)				
Tensile, psi	4175	3900	3975	3400
% Change	+1	+3	+10	-7
Elongation, %	210	230	265	290
% Change	-22	-34	-17	-29
Shore A Hardness	90	87	85	81
Points Change	+4	+4	+3	+5
Aged Properties, Circ. Air Oven – 70 Hrs. @ 250°F(121°C)				
Tensile, psi	4175	4075	3660	4090
% Change	+1	+7	+2	+12
Elongation, %	165	200	200	285
% Change	-39	-43	-38	-30
Shore A Hardness	92	88	88	84
Points Change	+6	+5	+6	+8

CLOSED CELL SPONGE INSULATION TUBING

Uniroyal

Flux	
Paracril® 2813	60.0
PVC Resin	40.0
Paraplex G-62	3.0
Mark 189A	2.0
Antimony Oxide	3.0
Hydral 710	60.0
Polygard®	1.0
Santicizer 148	20.0
Suprex Clay	25.0
Total	**214.0**

Mixing Procedures	
Banbury #2 Speed, Water Off	
0 Min:	Load Paracril®
1 Min:	Add all ingredients
At 121°C(250°F):	Raise and scrap ram
At 163°C(325°F):	Dump

Masterbatch	**PHR**
Flux	214.0
Mistron Vapor	30.0
Magcarb L	20.0
N-550 Black	10.0
Zinc Oxide	3.0
Stearic Acid	1.0
Octamine®	1.0
Chlorowax 70S	15.0
Santicizer 148	25.0
Celogen® AZ 130	17.0
Total	**336.0**

Mixing Procedures	
Banbury #2 Speed – Water on Full	
0 Min:	Load Flux
1 Min:	Add all remaining ingredients
At 107°C(225°F):	Raise and scrape ram
At 121°C(250°F):	Dump

CLOSED CELL SPONGE INSULATION TUBING
Continued

Acceleration	
Masterbatch	336.0
MBT	1.0
Sulfads	0.7
Methazate®	1.0
DPG	1.0
Sulfur	2.0
Celogen® OT	8.0
Total	**349.7**

Mixing Procedure	
Mill Mix or Low Speed Banbury Mix	
Banbury – Low Speed, Water On	
0 Min:	Load ½ MB, all ingredients and second ½ MB
At 60°C(140°F):	Raise and scrape ram
At 66°C(150°F):	Drop batch

Curing Conditions:	
Hot Air Oven – Precure:	6 Minutes @ 127°C(260°F)
Final Cure:	8 Minutes @ 171°C(340°F)
Expanded Density:	88 kg/m(5.5 lb/ft^3

CLOSED CELL SPONGE INSULATION TUBING

Uniroyal

Flux	
Paracril® 2813	50.0
PVC Resin	50.0
Paraplex G-62	3.0
Mark 189A	2.0
Antimony Oxide	5.0
Hydral 710	60.0
Polygard®	1.0
Santicizer 148	15.0
Suprex Clay	25.0
Total	**211.0**

Mixing Procedures	
Banbury #2 Speed, Water Off	
0 Min:	Load Paracril®
1 Min:	Add all ingredients
At 121°C(250°F):	Raise and scrap ram
At 163°C(325°F):	Dump

Masterbatch	PHR
Flux	211.0
Mistron Vapor	30.0
Magcarb L	20.0
N-550 Black	10.0
Zinc Oxide	2.0
Stearic Acid	1.0
Octamine®	1.0
Chlorowax 70S	15.0
Santicizer 148	15.0
Celogen® AZ 130	17.0
Total	**322.0**

Mixing Procedures	
Banbury #2 Speed – Water on Full	
0 Min:	Load Flux
1 Min:	Add all remaining ingredients
At 107°C(225°F):	Raise and scrap ram
At 121°C(250°F):	Dump

CLOSED CELL SPONGE INSULATION TUBING
Continued

Acceleration	
Masterbatch	322.0
MBT	1.0
Sulfads	0.7
Methazate®	1.0
DPG	1.0
Sulfur	2.0
Celogen® OT	8.0
Total	**335.7**
Mixing Procedure	
Mill Mix or Low Speed Banbury Mix	
Banbury – Low Speed, Water On	
0 Min:	Load ½ MB, all ingredients and second ½ MB
At 60°C(140°F):	Raise and scrape ram
At 68°C(150°F):	Drop batch
Curing Conditions: Hot Air Oven	
Precure:	6 Minutes @ 127°C(260°F)
Final Cure:	8 Minutes @ 171°C(340°F)
Expanded Density:	88 kg/m(5.5 lb.ft^3

VINYL CLOSED CELL SHEET SPONGE

Uniroyal

Flux	
Paracril® X2813	50.0
PVC Resin	50.0
Paraplex G-62	3.0
Mark 189A	2.0
Mistron Vapor	60.0
Suprex Clay	20.0
DOP	25.0
Polygard®	1.0
Total	**211.0**

Mixing Procedures	
Banbury, #2 Speed, Water Off	
0 Min:	Load Paracril® plus vinyl
1 Min:	Load all ingredients
At 160°C(320°F):	Dump

Masterbatch	**PHR**
Flux	211.0
Suprex Clay	50.0
Zinc Oxide	15.0
Stearic Acid	1.0
Octamine®	2.0
Celogen® AZ-130	17.0
DOP	30.0
Total	**326.0**

Mixing Procedures	
Banbury #2 Speed, Water on Full	
0 Min:	Load flux
1 Min:	Load all ingredients
At 110°C(230°F):	Dump

Cures	**Press Molded**	**Continuous**
Masterbatch	326.0	326.0
Ethazate®	0.4	0.8
MBTS	0.4	0.8
DOTG	0.4	0.8
Celogen® OT	8.0	8.0
Sulfur	1.0	2.0
Total	**336.2**	**338.4**

VINYL CLOSED CELL SHEET SPONGE
Continued

Mixing Procedure	
Mix on mill using standard milling procedures.	
Curing Conditions	
Press Molded:	
Precure ¾ inch thick mold	35 min. @ 129°C(265°F)
Expansion and final cure	30 min. @ 149°C(300°F)
Continuous:	
Precure	10 min. @ 121°C(250°F)
Final cure	10 min. @ 166°C(330°F)
Expanded Density:	88 kg/m (5.5 lb/ft^3)

VINYL CLOSED CELL SPONGE – FLOTATION

Uniroyal

Flux	
Paracril® X2813	40.0
PVC Resin	60.0
Paraplex G-62	3.0
Mark 189A	2.0
Mistron Vapor	60.0
Suprex Clay	20.0
DOP	25.0
Polygard®	1.0
Total	**211.0**

Mixing Procedures	
Banbury, #2 Speed, Water Off	
0 Min:	Load Paracril® 2813 plus vinyl
1 Min:	Load all ingredients
At 160°C(320°F):	Dump

Masterbatch	**PHR**
Flux	211.0
Suprex Clay	50.0
Zinc Oxide	15.0
Stearic Acid	1.0
Octamine®	2.0
Celogen® AZ-130	25.0
DOP	30.0
Total	**334.0**

Mixing Procedures	
Banbury #2 Speed, Water on Full	
0 Min:	Load flux
1 Min:	Load all ingredients
At 110°C(230°F):	Dump

	Press Molded, PPH	**Continuous, PPH**
Masterbatch	334.0	334.0
MEthazate®	0.5	1.0
MBT	0.5	1.0
DPG	0.5	1.0
Celogen® OT	5.0	5.0
Sulfur	1.0	2.0
Sulfads	0.4	0.7
Total	**341.9**	**344.7**

VINYL CLOSED CELL SPONGE - FLOTATION
Continued

Mixing Procedure	
Mix on mill using standard milling procedures.	
Curing Conditions	
Press Molded:	
Precure ¾ inch thick mold	35 min. @ 129°C(265°F)
Expansion and final cure	30 min. @ 149°C(300°F)
Continuous:	
Precure	10 min. @ 121°C(250°F)
Final cure	10 min. @ 166°C(330°F)
Expanded Density:	56 kg/m (3.5 lb/ft^3)

LOW DENSITY CLOSED CELL INSULATION

Uniroyal

Banbury Mix	
Paracril® OZO M50	100.0
Zinc Oxide	4.0
Stearic Acid	1.0
MT (N-990) Black	70.0
Hydral 710	25.0
Dioctyl Phthalate	20.0
Santicizer 141	15.0
Celogen® OT	25.0
Add on Mill	
DOTG	0.6
Oxaf®	0.6
Ethazate®	0.6
Sulfur	3.0
Total	**264.8**
Oven Cure 20 Minutes @ 121°C(250°F)	
Blown Density, kg/m^3 (lb/ft^3)	97.6(6.1)

COMPOUND TO MEET AMS 7272F
Zeon

		Specification
Zetpol 2010	40.0	
Zetpol 1010	60.0	
N-550 FEF	50.0	
PlastHall TOTM	7.5	
PlastHall DIDA	7.5	
Zinc Oxide	5.0	
PAT-44/04	0.25	
Naugard 445	1.5	
Vanox ZMTI	1.0	
HVA-2	4.0	
VC-60P	5.4	
Total	**182.15**	
Processing Properties		
Mooney Viscosity		
(1+4) @ 100°C(212°F)	74	
Mooney Scorch, MS (1+30) @125°C(257°F)		
Viscosity, min.	40.9	
T5, min.	15.8	
T35, min.	24.4	
ODR, Microdie, 100 CPM, 3° Arc @ 170°C(338°F)		
MI, dN.m	12.5	
MI, lbf.in.	14.1	
Mh, dN.m	88.2	
Mh, lbf.in	99.6	
ts2, min.	1.1	
t90, min.	13.2	
Cure, min.	20.0	
Vulcanizate Properties		
Hardness, Shore A, pts.	72	70±5
Modulus @ 100%, MPa (psi)	7.7(1112)	(500 min.)
Modulus @ 200%, MPa (psi)	21.9(3172)	
Tensile, MPa (psi)	26(3775)	1500 min.
Elongation, %	251	250 min.
SPECIFIC GRAVITY	1.16	

COMPOUND TO MEET AMS 7272F
Continued

Compression Set, Method B, plied disc		
70 Hr. @ 125°C(257°F)	15	
Compression Set, Method B, o-ring		
70 Hr. @ 125°C(257°F)	25.5	75 max.
Low Temperature Retraction		
TR-10, °C	-26	-26 min.
Aged Properties		
Aged in Air Oven 70 Hr. @ 125°C(257°F) - change		
Hardness, pts.	10	
Tensile, %	3	-25 max.
Elongation, %	-21	-50 max.
180° Bend, %	pass	
Aged in ASTM Test Fluid #101 70 Hr. @ 150°C(302°F) - change		
Hardness, pts	3	
Tensile, min.	3217	600 min.
Tensile, %	-15	-70 max.
Elongation, %	-12	-70 max.
Volume, %	3	0 to +15
Aged in ASTM Fuel B 70 Hr. @ 23°C(73°F) - change		
Hardness, pts	-15	
Tensile, %	-54	-60 max.
Elongation, %	-43	-55 max.
Volume, %	27.2	0 to +35
48 Hr. Dry Out @ 70°C(158°F)		
Volume, %	-7.8	-10 max.

VII.

Chlorinated PE
Chlorosulfonated PE

FUEL HOSE
DuPont Dow

Hypalon 4085	100
Magnesium Oxide	5
N762	60
Atomite	90
PE-200	3
Carbowax 3350	3
DOS	7.5
Sundex 790	22.5
PE-617A	3
MBTS	1
NBC	1
Tetrone A	1
Kenflex A-1	5
HVA-2	1
Total	**303**
Physical Properties – Original	
Tensile Strength, psi	1607
Elongation, %	353
Hardness, Shore A	71

FUEL HOSE COVER
Starting Point Formulation
DuPont Dow

Ingredients	**phr**
Tyrin CM 0136	100
Echo-S	3
Vanax 808	1
Marinco H	5
N-330	25
N-650	25
Atomite	60
TOTM	30
Wingstay 29	1
Irganox MD1024	1
Total	**250.8**
Processing	
Min Mooney Viscosity MS 1 @ 121°C (in.lbs.)	36.5
Mooney Scorch, MS 1 @ 121°C/3 Pt. Rise (min.)	21.5
ODR Cure @ 160°C	
M-L, in-lbs.	11.5
M-H, in-lbs.	58.0
Δ Torque, in-lbs.	47.5
Tc90, min.	13.8
Original Properties Cured @ 160°C/20’	
M-100, MPa	3.7
M-200, MPa	6.8
Ultimate Tensile, MPa	11.4
Ultimate Elongaiton, %	360
Hardness, Shore A	83
C-Set @ 150°C/20 hours, % Set	55
Tear, Die C, kN/m	41.6
LTB, °C	-31

FUEL HOSE COVER
Starting Point Formulation
Continued

Air Oven Aging @ 150°C/70 hours	
Tensile, % Δ	+9
Elongation, % Δ	-39
Hardness, Δ	+7
Oil Aging – Oil #3 @ 150°C/70 hours	
Volume Swell, %	47
Tensile, % Δ	-18
Elongation, % Δ	-63
Hardness, Δ	-32
Fuel Aging – ASTM Fuel B @ 23°C/70 hours	
Volume Swell, %	35
Tensile, % Δ	-20
Elongation, % Δ	-12
Hardness, Δ	-29

GENERAL PURPOSE HYDRAULIC HOSE COVER
R.T. Vanderbilt

Tyrin CM-0836	100.0
N-762 Carbon Black	75.2
Catalpo Clay	25.0
Maglite D	10.0
Santicizer 711	55.0
VANAX 808	1.0
ECHO S	3.0
Total	265.0
Density, Mg/m3	1.34
Oscillating Disk Rheometer at 160°C(320°F)	
ODR Cure Time, min.	4.4
ODR Torque, N.m (lb-in)	7.2(41)
Physical Properties	
Cured 20 min. @ 160°C(320°F)	
100% Modulus, MPa (psi)	3.7(540)
200% Modulus, MPa (psi)	6.7(960)
Tensile Strength, MPa (psi)	11.8(1700)
Elongation, %	510
Hardness, Shore A	70

POWER STEERING HOSE TUBE AND COVER

DuPont Dow

Hypalon 4085	75
Hypalon 6525	25
N762	75
TOTM	20
Magnesium Oxide	10
PE-200	5
Dicup 40C	6
TAC	3.3
PE-617A	3
Total	**222.3**
Physical Properties – Original	
Tensile Strength, psi	3001
Elongation, %	180
Hardness, Shore A	77

POWER STEERING RETURN HOSE
Starting Point Formulations
DuPont Dow

	PEROXIDE	THIADIAZOLE
Tyrin CM0136	---	100
Tyrin CM0730	100	---
Echo-S	---	3
Vanax 808	---	1
Vulcup 40KE	4	---
Trigonox 17/40	4	---
DAP	3.5	---
TAC	2	---
Maglite D	10	---
Magnesium Hydroxide	---	5
N-762	55	100
N-990	55	---
TOTM	40	40
Agerite Resin D	0.2	---
Wingstay 29	---	1
Irganox MD1024	---	1
Total	**273.7**	**251**
Processing		
Min. Mooney Viscosity MS 1 @ 121°C (in.lbs.)	23	37
Mooney Scorch, MS 1 @ 121°C/3 Pt. Rise	25	>25
ODR Cure @ 160°C		
M-L, in-lbs.	10	14
M-H, in-lbs.	78	51
Δ Torque, in-lbs.	68	37
Tc90, min.	20	13
Original Properties Cured @ 160°C/20’		
M-100, psi	760	1210
M-200, psi	---	1600
Ultimate Tensile, psi	2100	1690
Ultimate Elongation, %	230	260
Hardness, Shore A	77	88
C-Set @ 150°C/20 hours, % Set	33	72
Tear, Die C, ppi	---	230
LTB, °C	-38	-34

POWER STEERING RETURN HOSE
Starting Point Formulations
Continued

Air Oven Aging @ 150°C/70 hours	**PEROXIDE**	**Thiadiazole**
Tensile, % Δ	-5	+2
Elongation, % Δ	-19	-46
Hardness, Δ	+3	+8
Oil Aging – Oil #3 @ 150°C/70 hours		
Volume Swell, %	55	49
Tensile, % Δ	-23	-22
Elongation, % Δ	-23	-58
Hardness, Δ	-22	-21

GENERAL PURPOSE COVER
R.T. Vanderbilt

Hypalon 40	70.0
Hypalon 4085	30.0
Budene 1207	3.0
A-C 617 A Polyethylene	3.0
VANWAX H	3.0
Magnesium Oxide	5.0
Admex 746	5.0
VANOX NBC	1.0
Aromatic Plasticizer	30.0
Ester Plasticizer	20.0
THERMAX FLOFORM (N-990)	50.0
FEF Black (N-550)	25.0
Laminar Whiting	150.0
METHYL TUADS	2.0
Sulfur	1.0
Total	398.0
Density, Mg/m^3	1.66
Properties, Cured 30 Minutes at 153°C(307°F)	
Tensile Strength, MPa (psi)	9.3(1350)
Elongation, %	240
Hardness, Shore A	65

AUTO IGNITION WIRE
R.T. Vanderbilt

Tyrin 566		100.0
Maglite D		5.0
TAC		2.0
N-550 Carbon Black		30.0
Atomite Whiting		125.0
DIDP		30.0
VAROX 802		4.0
Mooney Viscosity ML (1+10) @ 121°C		
Minimum		50
Maximum		65
Oscillating Disk Rheometer (3°C), 30 min. @ 177°C		
Maximum Torque, N-m(in-lb)		13.0(110)
Minimum Torque, N-m(in-lb)		1.2(10)
Scorch Time, min.		1
Optimum Cure Time, min.		5
Optimum Torque, N-m(in-lb)		11.8(100)
	Press Cure	Steam Cure
Vulcanizate Properties	20 min. @ 160°C	60 sec. @ 240 psi
100% Modulus, MPa (psi)	3.8((555)	3.2(470)
Tensile Strength, MPa (psi)	11.4(1655)	10.3(1500)
Elongation, %	295	300
Hardness, Durometer A	78	76
Tear Strength, kN/m(pli)	2.8(16)	3.5(20)
Brittle Point °C(°F)	-30(-22)	
Moisture Absorption, 7 days @ 70°C		
Water, mg.cm^2 (mg/in^2)	22(140)	28(180)
Aged 70 hr. @ 136°C		
100% Modulus, MPa (psi)	7.3(1065)	6.6(965)
Hardness Change, Points	+11	+4
Tensile Retention, %	100	100
Elongation Retention, %	80	80
Aged ASTM Oil No. 2, 18 hr. @ 121°C		
100% Modulus, MPa (psi)	4.9(715)	4.6(670)
Hardness Change, Points	-4	+2
Tensile Strength Retention, %	310	110
Elongation Retention, %	95	90

AIR INTAKE DUCT
Starting Point Formulation
DuPont Dow

Tyrin CM 0136	100
Echo-S	3
Vanax 808	1
Marinco H	5
N-550	50
Hi-Sil 233	10
TOTM	35
Wingstay 29	1
Irganox MD1024	1
Total	**206**
Processing	
Min. Mooney Viscosity MS 1 @ 121°C(in-lbs.)	38.0
Mooney Scorch, MS 1 @ 121°C/3 Pt. Rise (min.)	25.0
ODR Cure @ 160°C	
M-L, in-lbs.	12.5
M-H, in-lbs.	52.0
Δ Torque, in-lbs.	39.5
Tc90, min.	13.0
Original Properties Cured @ 160°C/20'	
M-100, MPa	3.8
M-200, MPa	7.6
Ultimate Tensile, MPa	18.0
Ultimate Elongation, %	530
Hardness, Shore A	78
C-Set @ 100°C/22 hours, % Set	26
Tear, Die C, kN/m	52.9
LTB, °C	-34

AIR INTAKE DUCT
Starting Point Formulation
Continued

Air Oven Aging @ 150°C/70 hours	
Tensile, % Δ	-9
Elongation, % Δ	-48
Hardness, Δ	-12
Oil Aging – Oil #3 @ 150°C/70 hours	
Volume Swell, %	50
Tensile, % Δ	-51
Elongation, % Δ	-71
Hardness, Δ	-35
Fuel Aging – ASTM Fuel C @ 23°C/70 hours	
Volume Swell, %	74
Tensile, % Δ	-51
Elongation, % Δ	-44
Hardness, Δ	-35

ACID RESISTANT ROLL COMPOUND
DuPont Dow

Hypalon 40	100
Carbowax 4000	3
AC Polyethylene	3
SRF Carbon Black	70
Hysafe 510	10
TOTM	30
DiCup 40KE	7
TAC-DLC	5
Total	**228**
Physical Properties – Original	
Cured 30 minutes @ 307°F	
Tensile Strength, psi	2000
Elongation, %	250
Hardness, Shore A	65

POWER CABLE JACKET
DuPont Dow

Hypalon 40	100
Litharge 90% D	44
N550	5
N908	22
Calcined Clay	40
Vanwax H	6
Kenflex A-1	20
Aromatic Process Oil	15
Vanox NBC	3
MBTS	1
Tetrone A	1
HVA-2	1
Total	**258**
Physical Properties – Original	
Cured 1 minute @ 115 psi Steam	
Tensile Strength, psi	1875
Elongation, %	620

HPN CORD
R.T. Vanderbilt

Tyrin 566	100.0
Maglite D	5.0
Atomite Whiting	50.0
Buca Clay	60.0
DIDP	20.0
AGERITE RESIN D	0.2
SR-350 (TMPTM)	5.0
VAROX 802	3.0
Mooney Viscosity ML (1+10) @ 100°C	
Minimum	70
Maximum	95
Mooney Viscosity ML (1+10) @ 121°C	
Minimum	45
Maximum	70
Oscillating Disk Rheometer (3°C), 30 min. @ 177°C	
Maximim Torque, N-m(in-lb)	5.9(50)
Minimum Torque, N-m(in-lb)	1.2(10)
Scorch Time, min.	2
Optimum Cure Time, min.	8
Optimum Torque, N-m(in-lb)	5.9(50)
Vulcanizate Properties:	
Press Cure, 20 min. @ 160°C	
100% Modulus, MPa (psi)	4.6(675)
Tensile Strength, MPa (psi)	10.5(1520)
Elongation, %	540
Hardness, Durometer A	74
Aged 10 Days @ 113°C	
100% Modulus, MPa (psi)	8.0(1165)
Hardness Change, Points	+10
Tensile Retention, %	100
Elongation Retention, %	40
Aged ASTM No. 2 Oil, 18 hr. @ 121°C	
100% Modulus, MPa (psi)	5.7(830)
Hardness Change, Points	-7
Tensile Retention, %	100
Elongation Retention, %	65

WHITE ROOFING COMPOUND

DuPont Dow

Hypalon 45	100
Atomite Whiting	80
TiPure R-960	30
Versamag DC	6
Irganox 1010	1
Kemamide	1
Carbowax 3350	1.25
Tinuvin 622	0.8
Total	**220.05**
Physical Properties – Original	
Tensile Strength, psi	625
Elongation, %	150
Hardness, Shore A	86

LOW DISCOLORATION TRANSLUCENT ARTICLE

R.T. Vanderbilt

Hypalon 40	100.0
ERL-4221 Epoxy Resin	2.8
Carbowax 4000	1.0
VAROX DBPH	4.0
TAC	4.0
Total	111.8
Properties, Cured 30 minutes @ 153°C	
Hardness, Shore A	50
Tensile, MPa (psi)	25(3600)
Elongation, %	500
Density, Mg/m^3	1.16

DUROMETER 65 COMPOUND FOR BRASS ADHESION

PPG

CPE 0136		100.0
Silene 732D		60.0
Whiting		20.0
DOP		40.0
Magnesia		12.0
Stearic Acid		2.0
Sulfur		0.1
SR206		4.0
DCP 40%		6.0
Cure Rate MDR 160C, T50 minutes		10
Mooney Scorch 121C, T5 minutes		17
Mooney Viscosity, ML100		50
Cure: 30/40' @ 160C		
Durometer @ 23C		65
@ 100C		51
Stress/Strain	Original	Aged 700 hrs. @ 125C
M300, MPa	5.3	Brittle
Tensile	10	
Elongation, %	600	
Adhesion to Brass Coated Wire (6+3), ASTM 2224	Steam	Press
Cure: 40'/160C		
Pull-Out, N/25 mm	200	480
% Rubber Cover	50	100
Dynamic Modulus, DMA: 1 Hz; 8%		E', Gpa
-60C		1.89
-40		1.72
-20		1.34
0		0.37
10		0.100
20		0.042
30		0.028
Tg (E" maximum)		-8°C
Pendulum Rebound (Z), %		
23C		42
100C		46

DUROMETER 75, FABRIC ADHESION & BRASS ADHESION
PPG

			Banbury 1
CPE 0236			100.0
Silene 732D			60.0
DOP			40.0
Magnesium Oxide			10.0
Stearic Acid			2.0
R-F Resin			3.0
SR 206			6.0
			Banbury 2
DCP 40%			6.0
HMMM 65%			3.0
Total			**230.0**
Specific Gravity			1.32
Cure Rate T90: 160°C: T50			13 minutes 26 minutes
Mooney Scorch 130°C T5			6.4 minutes
Viscosity ML100			44
Garvey Extrusion, 120°C			
Die Swell			2%
Edge-Surface Rating			8A
Cure: 40’/160°C	Original	Aged 4 Wks. 100°C	Aged 1 Wk. 125°C
Durometer	76	91	77
M300, MPa (PSI)	6.6(970)	--	--
Tensile	9.8(1430)	12(1750)	9.9(1450)
Elongation, %	635%	360%	480%
Compression Set, 3 Days 100°C			62.8%
Pendulum Rebound (Z)			34.6%
At 100°C			42.8%
Adhesion to RFL Cord Sheet Laminated, 0.5 mm Skim			
Strip Bond N/25 mm (PPI)			130(30)
Adhesion to Brass Coated Wire (6 + 3)			
Pull-Out, N/25 mm (PPI)			560(130)

Notes:

VIII.

URETHANE

25 DUROMETER NON-BLACK SULFUR CURE

TSE

Millathane 76	100.0
AC Poly 617A	2.0
#15 Brown Sub	2.5
Cumar P-10	5.0
TP-95	28.0
Stantone Green	0.3
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5

Physical Properties

Press cure 15 minutes @ 149°C(300°F)

Durometer, Shore A	25
100% Modulus, psi	76
100% Modulus, MPa	0.52
200% Modulus, psi	122
200% Modulus, MPa	0.84
300% Modulus, psi	182
300% Modulus, MPa	1.25
Tensile Strength, psi	1906
Tensile Strength, MPa	13.14
Elongation, %	578
Tear Die C, pli	94
Tear Die C, kN/m	16.46

30 DUROMETER BLACK SULFUR CURE
TSE

Millathane 76	100.0
AC Poly 617A	2.0
#15 Brown Sub	2.5
Cumar P-10	5.0
TP-95 Oil	17.4
N-550 Black	5.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5
Physical Properties	
Press cure 15 minutes @ 149°C(300°F)	
Durometer, Shore A	30
100% Modulus, psi	112
100% Modulus, MPa	0.77
200% Modulus, psi	175
200% Modulus, MPa	1.21
300% Modulus, psi	248
300% Modulus, MPa	1.71
Tensile Strength, psi	3101
Tensile Strength, MPa	21.38
Elongation, %	641
Tear Die C, pli	156
Tear Die C, kN/m	27.32

33 SHORE A NON-BLACK SULFUR CURED

Uniroyal

Vibrathane 5008	100.0
Zinc Stearate	0.5
TP-95	18.0
Adaphax 758	2.5
AC 617A Polyethylene	2.5
MBTS	4.0
MBT	2.0
Caytur®4	1.0
Sulfur	1.5
Total	**132.0**
Press Cured 20 minutes @ 149°C(300°F)	
Hardness, Shore A	33
300% Modulus, MPa (psi)	1.3(190)
Tensile Strength, MPa (psi)	7.3(1060)
Elongation, %	700
Tear, Die C, kN/m (lb.in)	20.3(116)
Bashore Rebound, %	33
Compression Set, 22 hours @ 70°C	
% Set	91

37 SHORE A NON-BLACK SULFUR CURED

Uniroyal

Vibrathane 5008	100.0
Zinc Stearate	0.5
Hi-Sil 243LD	20.0
TP-95	40.0
Amberex B	10.0
MBTS	4.0
MBT	2.0
Caytur® 4	1.0
Sulfur	1.5
Total	**179.0**
Mooney Viscosity	
ML (1+4)@100°C	10
Press Cure, 15 minutes @ 160°C	
Hardness, Shore A	37
300% Modulus, MPa (psi)	1.7(245)
Tensile Strength, MPa (psi)	31.2(1920)
Elongation, %	725
Tear, Die C, kN/m (lb/in)	19.2(110)

40 DUROMETER NON-BLACK SULFUR CURE

TSE

Millathane 76	100.0
AC Poly 617A	2.0
#15 Brown Sub	2.5
Cumar P-10	5.0
TP-95 Oil	8.0
Hi-Sil 233	5.5
Red Oxide	5.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5

Physical Properties

Press cure 15 minutes @ 149°C(300°F)

Durometer, Shore A	40
100% Modulus, psi	113
100% Modulus, MPa	0.78
200% Modulus, psi	178
200% Modulus, MPa	1.23
300% Modulus, psi	257
300% Modulus, MPa	1.77
Tensile Strength, psi	3482
Tensile Strength, MPa	24.00
Elongation, %	740
Tear Die C, pli	154
Tear Die C, kN/m	26.97

40 A HARDNESS RANGE
TSE

	1	2
Millathane E-34	100.0	100.0
Zinc Stearate	0.5	0.5
MBTS	4.0	4.0
MBT	2.0	2.0
Thanecure	1.0	1.0
Sulfur	1.5	1.5
TP-95	15.0	----
Cumar P-10	20.0	20.0
Cure Time	15’	15’
Cure Temperature	310°F	310°F
Durometer, Shore A	43	45
Tensile Strength, psi	2650	3000
Modulus @ 300% psi	200	220
Elongation, %	500	500

50 A HARDNESS RANGE - NON-BLACK
TSE

	1	2
Millathane E-34	100.0	100.0
Zinc Stearate	0.5	0.5
MBTS	4.0	4.0
MBT	2.0	2.0
Thanecure	1.0	1.0
Sulfur	1.5	1.5
Cumar P-10	----	5.0
TP-95	5.0	----
Hi-Sil 233	5.0	----
Amberex BR	15.0	----
Dixie Clay	----	15.0
Cure Time	10’	20’
Cure Temperature	310°F	310°F
Durometer, Shore A	49	50
Tensile Strength, psi	3200	3300
Elongation, %	610	640
Tear (Die C), pli	100	120

50 A HARDNESS RANGE - BLACK
TSE

	1	2	3
Millathane E-34	100.0	100.0	100.0
Zinc Stearate	0.5	0.5	0.5
MBTS	4.0	4.0	4.0
MBT	1.0	2.0	1.0
Thanecure	1.0	1.0	1.0
Sulfur	1.5	1.5	1.0
Cumar P-10	---	10.0	---
TP-95	---	20.0	15.0
Benzoflex 9-88	15.0	---	---
N-774 (SRF)	30.0	---	---
N-220 (ISAF)	---	20.0	---
N-330 (HAF)	---	---	30.0
Cure Time	15’	20’	12’
Cure Temperature	310°F	310°F	310°F
Durometer, Shore A	50	52	52
Tensile Strength, psi	2900	2800	2550
Elongation, %	550	535	675
Tear (Die C), pli	130	120	130

50 DUROMETER NON-BLACK SULFUR CURE

TSE

Millathane 76	100.0
Zinc Stearate	0.5
AC Poly 617A	2.0
Hi-Sil 233	10.0
Titanium Dioxide	5.0
MBTS	4.0
MBT	1.0
Thanecure	1.0
Sulfur	1.5
Physical Properties	
Press cure 10 minutes @ 165°C(329°F)	
Durometer, Shore A	50
100% Modulus, psi	225
100% Modulus, MPa	1.55
200% Modulus, psi	381
200% Modulus, MPa	2.63
300% Modulus, psi	662
300% Modulus, MPa	4.56
Tensile Strength, psi	4993
Tensile Strength, MPa	34.49
Elongation, %	643
Tear Die C, pli	269
Tear Die C, kN/m	47.11

50 DUROMETER BLACK SULFUR CURE
TSE

Millathane 76	100.0
Zinc Stearate	0.5
AC Poly 617A	2.0
Hi-Sil 233	10.0
Laminar	20.0
N-550 Black	3.0
#15 Brown Sub	3.0
TP-95	15.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	2.0

Physical Properties
Press cure 13 minutes @ 155°C(311°F)

Durometer, Shore A	47
100% Modulus, psi	191
100% Modulus, MPa	1.32
200% Modulus, psi	339
200% Modulus, MPa	2.34
300% Modulus, psi	608
300% Modulus, MPa	4.19
Tensile Strength, psi	3448
Tensile Strength, MPa	23.77
Elongation, %	600
Tear Die C, pli	181
Tear Die C, kN/m	31.70

50 DUROMETER NON-BLACK PEROXIDE CURE

TSE

Millathane 76	100.0
Stearic Acid	0.5
AC Poly 617A	1.0
Hi-Sil 233	10.0
TP-95	20.0
Adaphax 758	3.0
Di-Cup 40C	3.0
Physical Properties	
Press cure 10 minutes @ 160°C(320°F)	
Durometer, Shore A	50
100% Modulus, psi	186
100% Modulus, MPa	1.28
200% Modulus, psi	331
200% Modulus, MPa	2.28
300% Modulus, psi	563
300% Modulus, MPa	3.88
Tensile Strength, psi	1648
Tensile Strength, MPa	11.36
Elongation, %	448
Tear Die C, pli	139
Tear Die C, kN/m	23.34

50 DUROMETER BLACK PEROXIDE CURE
TSE

Millathane 76	100.0
Stearic Acid	0.5
N-550 Black	30.0
TP-95	20.0
Adaphax 758	5.0
Di-Cup 40C	2.0
Physical Properties	
Press cure 9 minutes @ 160°C(320°F)	
Durometer, Shore A	50
100% Modulus, psi	218
100% Modulus, MPa	1.50
200% Modulus, psi	598
200% Modulus, MPa	4.12
300% Modulus, psi	1133
300% Modulus, MPa	7.81
Tensile Strength, psi	2511
Tensile Strength, MPa	17.31
Elongation, %	491
Tear Die C, pli	241
Tear Die C, kN/m	42.2

60 DUROMETER NON-BLACK SULFUR CURE

TSE

Millathane 76	100.0
Zinc Stearate	0.5
Translink 555	30.0
TP-95	5.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	2.0
Physical Properties	
Press cure 10 minutes @ 150°C(302°F)	
Durometer, Shore A	60
100% Modulus, psi	455
100% Modulus, MPa	3.14
200% Modulus, psi	1315
200% Modulus, MPa	9.07
300% Modulus, psi	2366
300% Modulus, MPa	16.31
Tensile Strength, psi	4413
Tensile Strength, MPa	30.43
Elongation, %	502
Tear Die C, pli	380
Tear Die C, kN/m	66.55

60 DUROMETER BLACK SULFUR CURE
TSE

Millathane 76	100.0
Zinc Stearate	0.5
N-550 Black	15.0
TP-95	5.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5
Physical Properties	
Press cure 10 minutes @ 155°C(311°F)	
Durometer, Shore A	60
100% Modulus, psi	329
100% Modulus, MPa	2.27
200% Modulus, psi	723
200% Modulus, MPa	4.98
300% Modulus, psi	1272
300% Modulus, MPa	8.77
Tensile Strength, psi	4171
Tensile Strength, MPa	28.76
Elongation, %	564
Tear Die C, pli	342
Tear Die C, kN/m	59.89

60 DUROMETER NON-BLACK PEROXIDE CURE

TSE

Millathane 76	100.0
Stearic Acid	0.5
Silane A-172	0.5
Hi-Sil 233	20.0
Sartomer SR-297	5.0
Di-Cup 40C	3.0
Physical Properties	
Press cure 10 minutes @ 160°C(320°F)	
Durometer, Shore A	60
100% Modulus, psi	244
100% Modulus, MPa	1.68
200% Modulus, psi	409
200% Modulus, MPa	2.81
300% Modulus, psi	685
300% Modulus, MPa	4.72
Tensile Strength, psi	2832
Tensile Strength, MPa	19.53
Elongation, %	649
Tear Die C, pli	230
Tear Die C, kN/m	40.28

60 DUROMETER BLACK PEROXIDE CURE
TSE

Millathane 76	100.0
Stearic Acid	0.5
Stabilizer 2013P	9.0
N-550 Black	25.0
Di-Cup 40C	3.0
Physical Properties	
Press cure 15 minutes @ 160°C(320°F)	
Durometer, Shore A	60
100% Modulus, psi	395
100% Modulus, MPa	2.72
200% Modulus, psi	1215
200% Modulus, MPa	8.38
300% Modulus, psi	2302
300% Modulus, MPa	15.87
Tensile Strength, psi	3639
Tensile Strength, MPa	25.09
Elongation, %	420
Tear Die C, pli	321
Tear Die C, kN/m	56.22

BLACK 60 SHORE A
Uniroyal

Adiprene FM	100.00
N330 Black	30.00
TP 95 Plasticizer (DBEEA)	10.00
Stearic Acid	0.25
Dicumyl Peroxide, 40%	3.00
Total	**143.25**
Compound Viscosity	
ML (1+4) @ 100°C	38
Mooney Scorch @ 121°C	
t3, minutes	22
Curemeter @ 160°C	
ts2, minutes	1.7
tc90, minutes	10.8
Press Cure 15 minutes @ 160°C	
Hardness, Shore A	60
100% Modulus, psi (MPa)	340(2.3)
300% Modulus, psi (MPa)	1640(11.3)
Tensile Strength, psi (MPa)	2930(20.2)
Elongation, %	460
Tear, Die C, lb/in (kN/m)	280(49)
Split Tear, lb/in (kN/m)	31(5.4)
Compression Set	
22 hours @ 70°C, % Set	19
Bashore Rebound, %	54

60 A HARDNESS RANGE - NON-BLACK
TSE

Millathane E-34	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5
Cumar P-10	10.0
Hi-Sil 233	30.0
Cure Time	10’
Cure Temperature	310°F
Durometer, Shore A	60
Tensile Strength, psi	4400
300% Modulus, psi	950
Elongation, %	770
Tear (Die C) pli	175
Compression Set, 22 Hours @ 158°F	40

60 A HARDNESS RANGE - BLACK
TSE

	1	2
Millathane E-34	100.0	100.0
Zinc Stearate	0.5	0.5
MBTS	4.0	4.0
MBT	2.0	2.0
Thanecure	1.0	1.0
Sulfur	1.5	1.5
Cumar P-10	10.0	7.0
N-774 (SRF)	30.0	----
N-220 (ISAF)	----	20.0
Cure Time	10’	10’
Cure Temperature	310°F	310°F
Durometer, Shore A	63	65
Tensile Strength, psi	4700	5200
300% Modulus, psi	1200	1400
Elongation, %	550	550
Tear (Die C), pli	150	220
Compression Set, 22 Hours @ 158°F	35	42

70 A HARDNESS RANGE - NON-BLACK
TSE

Millathane E-34	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5
Cumar P-10	10.0
Hi-Sil 233	40.0
Cure Time	15’
Cure Temperature	310°F
Durometer, Shore A	75
Tensile Strength, psi	3400
300% Modulus, psi	700
Elongation, %	550

70 A HARDNESS RANGE - BLACK
TSE

	1	2
Millathane E-34	100.0	100.0
Zinc Stearate	0.5	0.5
MBTS	4.0	4.0
MBT	1.0	1.0
Thanecure	0.5	0.5
Sulfur	1.5	1.0
Cumar P-10	10.0	15.0
N-220 (ISAF)	30.0	----
N-330 (HAF)	----	45.0
Cure Time	30’	30’
Cure Temperature	285°F	285°F
Durometer, Shore A	70	72
Tensile Strength, psi	5000	4300
300% Modulus, psi	2300	2000
Elongation, %	540	530

70 DUROMETER NON-BLACK SULFUR CURE
TSE

Millathane 76	100.0
Zinc Stearate	0.5
AC Poly 617A	1.0
Translink 555	55.0
Cumar P-10	5.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5

Physical Properties
Press cure 15 minutes @ 155°C(311°F)

Durometer, Shore A	68
100% Modulus, psi	570
100% Modulus, MPa	3.93
200% Modulus, psi	1680
200% Modulus, MPa	11.58
300% Modulus, psi	2640
300% Modulus, MPa	18.20
Tensile Strength, psi	3800
Tensile Strength, MPa	26.20
Elongation, %	490
Tear Die C, pli	415
Tear Die C, kN/m	72.68

70 DUROMETER BLACK SULFUR CURE
TSE

Millathane 76	100.0
Zinc Stearate	0.5
N-550 Black	35.0
TP-95	5.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5

Physical Properties
Press cure 10 minutes @ 155°C(311°F)

Durometer, Shore A	70
100% Modulus, psi	669
100% Modulus, MPa	4.61
200% Modulus, psi	1438
200% Modulus, MPa	9.91
300% Modulus, psi	2354
300% Modulus, MPa	16.23
Tensile Strength, psi	3433
Tensile Strength, MPa	23.67
Elongation, %	490
Tear Die C, pli	446
Tear Die C, kN/m	78.11

70 DUROMETER NON-BLACK PEROXIDE CURE
TSE

Millathane 76	100.0
Stearic Acid	0.5
Hi-Sil 233	30.0
Sartomer SR-297	3.0
Di-Cup 40C	2.0
Physical Properties	
Press cure 15 minutes @ 160°C(320°F)	
Durometer, Shore A	70
100% Modulus, psi	480
100% Modulus, MPa	3.31
200% Modulus, psi	984
200% Modulus, MPa	6.78
300% Modulus, psi	2059
300% Modulus, MPa	14.20
Tensile Strength, psi	3560
Tensile Strength, MPa	24.55
Elongation, %	386
Tear Die C, pli	256
Tear Die C, kN/m	44.83

70 DUROMETER BLACK PEROXIDE CURE
TSE

Millathane 76	100.0
Stearic Acid	0.5
Struktol WB222	0.2
TP-95	4.0
N-550 Black	35.0
Di-Cup 40C	2.0
Physical Properties	
Press cure 15 minutes @ 160°C(320°F)	
Durometer, Shore A	70
100% Modulus, psi	462
100% Modulus, MPa	3.19
200% Modulus, psi	1572
200% Modulus, MPa	10.84
300% Modulus, psi	2805
300% Modulus, MPa	19.34
Tensile Strength, psi	3429
Tensile Strength, MPa	23.64
Elongation, %	363
Tear Die C, pli	318
Tear Die C, kN/m	55.69

73 SHORE A BLACK SULFUR CURED
Uniroyal

Adiprene CM	100.00
Zinc Stearate	0.50
N330 Black	45.00
Cumar R-16	15.00
MBTS	4.00
MBT	1.00
Caytur® 4	0.35
Sulfur	0.75
Total	**166.60**
Press Cured 60 minutes @ 142°C(287°F)	
Hardness, Shore A	73
300% Modulus, MPa (psi)	17.5(2550)
Tensile Strength, MPa (psi)	34.5(5000)
Elongation, %	510
Tear Die A (Graves), N/mm (lb/in)	67(385)
Compression Set, 22 hours @ 70°C, %	19

78 SHORE A BLACK PEROXIDE CURED

Uniroyal

Adiprene CM	100.00
Stearic Acid	0.25
N330 Black	45.00
TP-95	10.00
Saret 500	10.00
Dicup 40KE	3.50
Total	**168.75**
Press Cured 20 minutes @ 154°C(310°F) + Post Cure 16 hours @ 121°C(250°F)	
Hardness, Shore A	78
100% Modulus, MPa (psi)	9.6(1390)
Tensile Strength, MPa (psi)	16.7(2430)
Elongation, %	160
Compression Set	
22 hours @ 70°C, %	14

80 DUROMETER NON-BLACK SULFUR CURE
TSE

Millathane 76	100.0
Zinc Stearate	0.5
Cumar P10	10.0
Hi-Sil 233	50.0
AC Poly 617A	2.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5

Physical Properties
Press cure 15 minutes @ 155°C(311°F)

Durometer, Shore A	80
100% Modulus, psi	250
100% Modulus, MPa	1.72
200% Modulus, psi	436
200% Modulus, MPa	3.0
300% Modulus, psi	7.38
300% Modulus, MPa	5.09
Tensile Strength, psi	2222
Tensile Strength, MPa	20.15
Elongation, %	671
Tear Die C, pli	294
Tear Die C, kN/m	51.49

80 DUROMETER BLACK SULFUR CURE
TSE

Millathane 76	100.0
Zinc Stearate	0.5
TP-95	10.0
N-330 Black	51.0
AC Poly 617A	1.5
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5

Physical Properties
Press cure 15 minutes @ 155°C(311°F)

Durometer, Shore A	80
100% Modulus, psi	812
100% Modulus, MPa	5.60
200% Modulus, psi	1731
200% Modulus, MPa	11.93
300% Modulus, psi	2522
300% Modulus, MPa	17.39
Tensile Strength, psi	3499
Tensile Strength, MPa	24.12
Elongation, %	495
Tear Die C, pli	465
Tear Die C, kN/m	81.44

80 DUROMETER NON-BLACK PEROXIDE CURE
TSE

Millathane 76	100.0
Stearic Acid	0.5
SR-297	7.5
Hi-Sil 233	25.0
AC Poly 617A	2.0
Di-Cup 40C	3.0
Physical Properties	
Press cure 15 minutes @ 160°C(320°F)	
Durometer, Shore A	80
100% Modulus, psi	807
100% Modulus, MPa	5.56
200% Modulus, psi	1754
200% Modulus, MPa	12.09
300% Modulus, psi	----
300% Modulus, MPa	----
Tensile Strength, psi	3341
Tensile Strength, MPa	23.04
Elongation, %	296
Tear Die C, pli	202
Tear Die C, kN/m	35.38

80 DUROMETER BLACK PEROXIDE CURE
TSE

Millathane 76	100.0
Stearic Acid	0.5
TP-95	10.0
N-774	70.0
SR 297	7.5
Di-Cup 40C	3.0
Physical Properties	
Press cure 15 minutes @ 160°C(320°F)	
Durometer, Shore A	80
100% Modulus, psi	986
100% Modulus, MPa	6.80
200% Modulus, psi	2349
200% Modulus, MPa	16.20
300% Modulus, psi	----
300% Modulus, MPa	----
Tensile Strength, psi	2642
Tensile Strength, MPa	18.22
Elongation, %	251
Tear Die C, pli	200
Tear Die C, kN/m	35.03

80 A HARDNESS RANGE - BLACK
TSE

	1	2
Millathane E-34	100.0	100.0
Zinc Stearate	0.5	0.5
MBTS	4.0	4.0
MBT	2.0	2.0
Thanecure	1.0	1.0
Sulfur	1.5	1.5
Cumar P-10	5.0	10.0
N-220 (ISAF)	45.0	----
N-330 (HAF)	----	60.0
Cure Time	20’	20’
Cure Temperature	310°F	310°F
Durometer, Shore A	78	84
Tensile Strength, psi	3700	3250
Elongation, %	340	300
Tear (Die C), pli	320	245

80 A HARDNESS RANGE - NON-BLACK
TSE

Millathane E-34	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5
Cumar P-10	10.0
Hi-Sil 233	60.0
Cure Time	30’
Cure Temperature	310°F
Durometer, Shore A	80
Tensile Strength, psi	3500
Elongation, %	450
Tear (Die C), pli	240

90 A HARDNESS RANGE - BLACK
TSE

	1	2	3
Millathane E-34	100.0	100.0	100.0
Zinc Stearate	0.5	0.5	0.5
MBTS	4.0	4.0	4.0
MBT	1.0	1.0	1.0
Thanecure	0.5	0.5	0.5
Sulfur	1.0	1.0	1.0
Cumar P-10	10.0	10.0	15.0
N-220 (ISAF)	20.0	----	75.0
N-330 (HAF)	----	80.0	----
Hi-Sil 233	60.0	----	----
Cure Time	30’	30’	30’
Cure Temperature	285°F	285°F	285°F
Durometer, Shore A	88	89	90
Tensile Strength, psi	3300	3800	4000
300% Modulus, psi	1000	1400	1800
Elongation, %	400	300	310
Tear (Die C) pli	180	200	240
Compression Set 22 Hours @ 158°F	70	50	44

90 A HARDNESS RANGE - NON-BLACK
TSE

Millathane E-34	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	1.0
Thanecure	0.5
Sulfur	1.0
Cumar P-10	15.0
Hi-Sil 233	80.0
Cure Time	45’
Cure Temperature	285°F
Durometer, Shore A	88
Tensile Strength, psi	2900
300% Modulus, psi	900
Elongation, %	350
Tear (Die C) pli	170
Compression Set 22 Hours @ 158°F	80

90 DUROMETER NON-BLACK SULFUR CURE
TSE

Millathane 76	100.0
Zinc Stearate	0.5
Mistron Vapor	60.0
Cumar P10	5.0
Hi-Sil 233	30.0
Pliolite S6B	10.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	2.0

Physical Properties
Press cure 15 minutes @ 155°C(311°F)

Durometer, Shore A	90
100% Modulus, psi	726
100% Modulus, MPa	5.00
200% Modulus, psi	973
200% Modulus, MPa	6.71
300% Modulus, psi	1140
300% Modulus, MPa	7.86
Tensile Strength, psi	1810
Tensile Strength, MPa	12.48
Elongation, %	510
Tear Die C, pli	322
Tear Die C, kN/m	56.39

90 DUROMETER BLACK SULFUR CURE

TSE

Millathane 76	100.0
Zinc Stearate	0.5
Struktol WB222	0.5
Cumar R-3	10.0
N-550 Black	60.0
AC Poly 617A	1.0
MBTS	4.0
MBT	2.0
Thanecure	1.0
Sulfur	1.5

Physical Properties

Press cure 15 minutes @ 155°C(311°F)

Durometer, Shore A	88
100% Modulus, psi	1300
100% Modulus, MPa	8.96
200% Modulus, psi	2170
200% Modulus, MPa	14.96
300% Modulus, psi	2450
300% Modulus, MPa	16.89
Tensile Strength, psi	2600
Tensile Strength, MPa	17.93
Elongation, %	350
Tear Die C, pli	360
Tear Die C, kN/m	63.05

90 DUROMETER NON-BLACK PEROXIDE CURE
TSE

Millathane 76	100.0
Stearic Acid	0.5
Poly-AC 617A	2.0
Hi-Sil 233	60.0
SR-297	7.5
Di-Cup 40C	3.0
Diethyleneglycol	1.0

Physical Properties
Press cure 7 minutes @ 160°C(311°F)

Durometer, Shore A	90
100% Modulus, psi	1138
100% Modulus, MPa	7.85
200% Modulus, psi	1735
200% Modulus, MPa	11.96
300% Modulus, psi	2568
300% Modulus, MPa	17.71
Tensile Strength, psi	2568
Tensile Strength, MPa	17.71
Elongation, %	300
Tear Die C, pli	331
Tear Die C, kN/m	57.97

90 DUROMETER BLACK PEROXIDE CURE

TSE

Millathane 76	100.0
Stearic Acid	0.5
SR 350	10.0
N-330	50.0
AC Poly 617A	1.0
Di-Cup 40C	3.0

Physical Properties

Press cure 15 minutes @ 160°C(311°F)

Durometer, Shore A	90
100% Modulus, psi	1648
100% Modulus, MPa	11.36
200% Modulus, psi	3114
200% Modulus, MPa	21.47
300% Modulus, psi	----
300% Modulus, MPa	----
Tensile Strength, psi	3161
Tensile Strength, MPa	21.79
Elongation, %	201
Tear Die C, pli	254
Tear Die C, kN/m	44.48

92 SHORE A BLACK COMPOUND, SULFUR CURE
Uniroyal

Adiprene® FM	100.0
Zinc Stearate	0.50
N330 Black	80.00
Cumar R-17	10.00
MBTS	4.00
MBT	2.00
Caytur® 4	1.00
Sulfur	2.00
Total	**199.50**
Mooney Viscosity	
ML (1+4) @ 100°C	106
Press Cured 10 minutes @ 160°C(320°F)	
Hardness, Shore A	92
100% Modulus, MPa (psi)	14.1(2040)
Tensile Strength, MPa (psi)	25.6(3710)
Elongation, %	250
Tear, Die C, kN/m (lb/in)	89(510)
Bashore Rebound, %	29
Compression Set, 22 Hours @ 70°C, %	46
Oven Aged 70 Hours @ 100°C(212°F)	
Hardness, Shore A	95
Hardness, Points Change	+3
Tensile Strength, MPa (psi)	29.2(4230)
Tensile Strength, % Change	+7
Elongation, %	160
Elongation, % Change	-36

92 SHORE A BLACK COMPOUND, PEROXIDE CURED

Uniroyal

Vibrathane 5004	100.00
Stearic Acid	0.25
N330 Black	30.00
Cab-O-Sil M5	2.50
SR-350	20.00
Dicup 40C	5.00
Total	**157.75**
Mooney Viscosity	
ML (1+4) @ 100°C	48
Press Cured 20 minutes @ 160°C(320°F) + 30 minutes @135°C(275°F) Postcure	
Hardness, Shore A	92
100% Modulus, MPa (psi)	15.9(2310)
Tensile Strength, MPa (psi)	28.6(4150)
Elongation, %	160
Tear, Die C, kN/m(lb/in)	52(300)
Compression Set	
22 Hours @ 70°C, %	12
22 Hours @ 125°C, %	69

IX.

Silicone Fluoroelastomers

FUEL HOSE
DuPont Dow

Viton B-200	97.2
Calcium Hydroxide	3
N990	25
Maglite D	3
Blanc Fixe	25
Carnuba Wax	2
Viton Curative #20	0.5
Viton Curative #50	2.3
Total	**158**
Expected Physical Properties – Original	
Tensile Strength, psi	1000
Elongation, %	310
Hardness, Shore A	83

HOSE/EXTRUSION APPLICATIONS
Dyneon

	1	2
Fluorel™ FE-5730Q*	100	
Fluorel FE-5830Q*		100
MT Black (N990)	30	30
MgO	3	3
$Ca(OH)_2$	6	6
Physical Properties		
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C		
%F	69.2	70.5
S.G.	1.86	1.90
Mooney Visc. (1+10) @ 121°C	32	33
TR 10 (°C)	-12	-7
Tensile (psi)	1460	1600
Elongation (%)	330	250
M100 (psi)	375	640
Durometer, Shore A (pts)	71	80
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	45	44
Rheological Properties		
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.		
177°C (350°F)		
ML (in-lbs)	1.1	1.0
ts2 (min)	1.3	2.0
t'50 (min)	1.4	2.3
t'90 (min)	1.9	3.3
MH (in-lbs)	9.8	15.4
200°C (392°F)		
ML (in-lbs)		
ts2		
t'50		
t'90		
MH (in-lbs)		

* Incorporated cure polymer

HOSE/EXTRUSION APPLICATIONS

Dyneon

	3	4	5	6
Fluorel™ FC-2120*	100			
Fluorel FC-2182*		100		
Fluorel FT-2320*			100	
Fluorel FX-11818*				100
MT Black (N990)	30	30	30	30
MgO	3	3	3	3
$Ca(OH)_2$	6	6	6	6
Physical Properties				
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C				
%F	65.9	65.9	69.0	68.6
S.G.	1.80	1.80	1.86	1.80
Mooney Visc. (1+10) @ 121°C	23	30	23	28
TR 10 (°C)	-18	-18	-12	-14
Tensile (psi)	2140	2200	2000	1800
Elongation (%)	200	265	230	290
M100 (psi)	850	550	750	490
Durometer, Shore A (pts)	75	70	79	74
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	16	22	39	34
Rheological Properties				
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.				
177°C (350°F)				
ML (in-lbs)	0.9	1.2	1.4	1.0
ts2 (min)	1.3	0.8	1.3	1.2
t'50 (min)	1.6	0.9	1.8	1.5
t'90 (min)	2.4	1.5	3.0	2.0
MH (in-lbs)	20.0	13.4	22.5	13.7
200°C (392°F)				
ML (in-lbs)				0.7
ts2				0.6
t'50				0.7
t'90				0.8
MH (in-lbs)				11.5

*Incorporated cure polymer

SILICONE SEAL COMPOUND
R.T. Vanderbilt

Select-Sil LZB-812 Base	100.0
Magnesium Oxide	4.0
Red Iron Oxide	1.0
VANOX DBPH-50	0.85
Total	105.85
Physical Properties	
Tensile, MPa (psi)	5.8(840)
100% Modulus, MPa (psi)	4.8(700)
Elongation, %	150
Hardness, Shore A	78

FLUOROSILICONE SEAL COMPOUND

R.T. Vanderbilt

FSE 262OU181	100.0
VANOX DBPH-50	1.0
Total	101.0
Physical Properties	
Tensile, MPa (psi)	8.6(1250)
100% Modulus, MPa (psi)	2.4(350)
Elongation, %	350
Hardness, Shore A	62

AUTOMOTIVE FLUOROELASTOMER FUEL SEALS

Ausimont

Tecnoflon FOR 4391	100
Magnesium Oxide (High Activity)	3
Calcium Hydroxide	6
MT N-990 Carbon Black	30
Physical Properties Press Cure 10 minutes @ 177°C Post Cure 8 hours + 16 hours @ 250°C	
Hardness, Shore A (points)	80
Tensile Strength, psi	2105
Elongation, %	207
100% Modulus, psi	914
Compression Set (-214 O-rings) 70 hours @ 200°C, %	24
Chemical Resistance Immersion 70 hours @ 23°C Reference Fuel C + 15% Methanol	
Hardness Change, points	-6
Tensile Change, %	-23
Elongation Change, %	+5
Volume Change, %	+6

NON-BLACK VALVE STEM SEALS

DuPont Dow

Viton A-500	98
Calcium Hydroxide	3
Maglite D	6
RC-R-7014	0.5
Nyad 400	30
Red Iron Oxide	5
VPA #3	0.7
Viton Curative #50	1.5
Total	**144.7**
Expected Physical Properties – Original	
Tensile Strength, psi	1750
Elongation, %	340
Hardness, Shore A	71
Compression Set	
70 hours @ 170°C, %	20

LOW TEMPERATURE FLUOROELASTOMER SERVICE SEALS

AUSIMONT

Tecnoflon P710	100
Luperco 101XL	3
TAIC, 75% Dispersion	4
Zinc Oxide	5
MT N-990 Carbon Black	30
Physical Properties	
Press Cure 10 minutes @ 177°C	
Post Cure 8 hours + 16 hours @ 230°C	
Hardness Shore A, points	69
Tensile Strength, psi	2760
Elongation, %	200
100% Modulus, psi	815
Compression Set (-214 O-rings) 70 hours @ 200°C, %	35
Low Temperature Properties	
TR10, °C	-30
TR30, °C	-26
TR50, °C	-24

FLUOROELASTOMER SHAFT SEALS

Ausimont

Tecnoflon FOR 60K	100
Magnesium Oxide (High Activity)	9
Calcium Hydroxide	6
Barium Sulfate	30
Polymist L206	30
Red Iron Oxide	5
Carnuba Wax	2
Physical Properties	
Press Cure 10 minutes @ 170°C	
Post Cure 8 hours + 16 hours @ 230°C	
Hardness, Shore A, points	79
Tensile Strength, psi	1640
Elongation, %	260
100% Modulus, psi	726
Coefficient of Friction	
20 N Load @ 600 rpm:	
After 5 seconds	0.92
After 10 minutes	0.67
Delta Temperature after 10 minutes , °C	28
Coefficient of Friction	
20 N Load @ 1000 rpm:	
After 5 seconds	0.62
After 10 minutes	0.22
Delta Temperature after 10 minutes, °C	18

FLUOROCARBON SEAL COMPOUNDS
R.T. Vanderbilt

	1	2
Fluorel 2181	100.0	----
Aflas 200	---	100.0
THERMAX (N-990)	30.0	30.0
Calcium Hydroxide	6.0	6.0
Magnesium Oxide	3.0	---
Carnauba Wax	---	0.75
VAROX DBPH-50	---	2.5
Coagent TAIC	---	2.5
Total	139.0	141.75
Physical Properties		
Tensile, MPa (psi)	15.2(2200)	14.8(2140)
100% Modulus, MPa (psi)	4.0(580)	4.6(670)
Elongation, %	250	230
Hardness, Shore A	73	72

O-RING GENERAL PURPOSE, INJECTION MOLDING (MIL-R-83248)

Ausimont

	Specification	Type I (-214 O-rings)
Tecnoflon FOR 423/U		100
Magnesium Oxide (High Activity)		3
Calcium Hydroxide		6
MT N-990 Carbon Black		30
Physical Properties Press Cure 10 minutes @ 170°C Post Cure 8 hours + 16 hours @ 250°C		
Hardness, Shore A, points	75±5	74
Tensile Strength, psi	1400 min.	1615
Elongation, %	125 min.	200
Compression Set (-214 O-rings)		
22 hours @ 200°C, %	15 max.	10.5
166 hours @ 175°C, %	20 max.	12.5
Chemical Resistance Immersion 70 hours @ 23°C Reference Fuel TT-S-735 Type III		
Hardness Change, points	±5	-1
Tensile Change, %	-20 max.	-10
Elongation Change, %	-20 max.	-7
Volume Change, %	0.5 to 10	1.4
Chemical Resistance Immersion 70 hours @ 175°C Reference Oil AMS 3021		
Hardness Change, points	-15 to 0	-8
Tensile Change, %	-30 max.	-20
Elongation Change, %	-20 max.	+5
Volume Change, %	1 to 20	+14
Compression Set, %	10 max.	4

O-RING APLICATIONS
Dyneon

Recipe	1	2	3	4
Fluorel™ FE-5610Q*	100			
Fluorel FE-5620Q*		100		
Fluorel FE-5621Q*			100	
Fluorel FE-5623Q*				100
MT Black (N990)	30	30	30	30
MgO	3	3	3	3
$Ca(OH)_2$	6	6	6	6

Physical Properties Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C				
%F	65.9	65.9	65.9	65.9
S.G.	1.80	1.80	1.80	1.80
Mooney Visc. (1+10) @ 121°C	9	23	23	23
TR 10 (°C)	-18	-18	-18	-18
Tensile (psi)	1930	2240	2240	2400
Elongation (%)	210	195	195	180
M100 (psi)	800	950	950	1060
Durometer, Shore A (pts)	75	77	77	79
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	21	13	13	13

Rheological Properties Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.				
177°C (350°F)				
ML (in-lbs)	0.3	0.7	0.7	0.7
ts2 (min)	2.7	2.3	2.3	104
t'50 (min)	3.0	2.6	2.6	1.6
t'90 (min)	4.2	3.7	3.7	2.3
MH (in-lbs)	15.6	22.4	22.4	23.0
200°C (392°F)				
ML (in-lbs)	0.3	0.5	0.5	0.5
ts2	1.2	0.8	0.8	0.4
t'50	1.3	0.9	0.9	0.5
t'90	1.5	1.1	1.1	0.7
MH (in-lbs)	14.0	21.0	21.0	21.0

* Incorporated cure polymer

O-RING APLICATIONS

Dyneon

Recipe	5	6	7	8
Fluorel™ FE-5640Q*	100			
Fluorel FE-5641Q*		100		
Fluorel FE-5660Q*			100	
Fluorel FE-5840Q*				100
MT Black (N990)	30	30	30	30
MgO	3	3	3	3
$Ca(OH)_2$	6	6	6	6
Physical Properties				
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C				
%F	65.9	65.9	65.9	70.1
S.G.	1.80	1.80	1.80	1.86
Mooney Visc. (1+10) @ 121°C	40	40	60	37
TR 10 (°C)	-18	-18	-18	-7
Tensile (psi)	2370	2340	2400	2000
Elongation (%)	200	185	200	210
M100 (psi)	1050	970	1150	980
Durometer, Shore A (pts)	77	76	77	84
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	11	11	9	26
Rheological Properties				
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.				
177°C (350°F)				
ML (in-lbs)	1.5	1.4	2.3	1.7
ts2 (min)	2.1	2.2	1.9	1.3
t'50 (min)	2.7	2.8	2.6	1.6
t'90 (min)	3.7	3.8	3.5	2.0
MH (in-lbs)	24.8	24.4	26.3	26.6
200°C (392°F)				
ML (in-lbs)	1.3	1.2	2.3	1.7
ts2	0.7	0.6	0.6	0.4
t'50	0.8	0.7	0.7	0.5
t'90	1.0	0.8	0.8	0.6
MH (in-lbs)	21.7	20.4	24.4	24.0

* Incorporated cure polymer

O-RING APLICATIONS
Dyneon

Recipe	**9**	**10**	**11**	**12**	**13**
Fluorel™ FC-2110Q*	100				
Fluorel FC-2121*		100			
Fluorel FC-2174*			100		
Fluorel FC-2179*				100	
Fluorel FC-2180*					100
MT Black (N990)	30	30	30	30	30
MgO	3	3	3	3	3
$Ca(OH)_2$	6	6	6	6	6
Physical Properties					
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C					
%F	65.9	65.9	65.9	65.9	65.9
S.G.	1.80	1.80	1.80	1.80	1.80
Mooney Visc.(1+10)@121°C	9	23	40	80	40
TR 10 (°C)	-18	-18	-18	-18	-18
Tensile (psi)	2010	2375	2450	2475	2370
Elongation (%)	170	180	180	180	180
M100 (psi)	950	1025	1050	1100	1025
Durometer, Shore A (pts)	77	77	78	76	75
Compression Set	19	14	12	10	12
(ASTM D395, Method B, 70 hrs. @ 200°C)					
Rheological Properties					
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.					
177°C (350°F)					
ML (in-lbs)	0.3	0.8	1.5	3.6	1.5
ts2 (min)	1.5	1.4	1.1	1.3	1.3
t'50 (min)	1.7	1.7	1.4	1.9	1.5
t'90 (min)	2.7	2.4	1.9	2.5	2.1
MH (in-lbs)	16.6	23.3	25.0	28.7	25.5
200°C (392°F)					
ML (in-lbs)		0.7			
ts2		0.5			
t'50		0.6			
t'90		0.8			
MH (in-lbs)		21.0			

*Incorporated cure polymer

DUROMETER 50 COMPOUND FOR RESILIENCE, KEYPADS
PPG

VMQ Gum	100.0
Polysiloxane Fluid	4.0
Hi-Sil 915	40.0
DBPH	0.8
Total	144.8
Specific Gravity	1.14
Plasticity (Williams)	
1 Day	1.42 mm
7 Days	1.50 mm
Cure: 10’/170°C; Post Cure: 1 hour/250°C	
Durometer	51
M100, MPa (PSI)	1.5(220)
M300	5.0(730)
Tensile	7.2(1050)
Elongation	390%
Die B Tear, kN/m (PPI)	12.6(72)
Cure 15’/170°C;	
Bashore Rebound	64%
Compression Set, 22 hrs. 177°C	12.8%

MOLDED GOODS APPLICATIONS
Dyneon

	1	2	3
Fluorel™ FE-5622Q*	100		
Fluorel FE-5642Q*		100	
Fluorel FE-5840Q*			100
MT Black (N990)	30	30	30
MgO	3	3	3
$Ca(OH)_2$	6	6	6
Physical Properties			
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C			
%F	65.9	65.9	70.2
S.G.	1.80	1.80	1.86
Mooney Visc.(1+10)@121°C	22	40	37
TR 10 (°C)	-18	-18	-7
Tensile (psi)	2250	2312	2000
Elongation (%)	235	220	210
M100 (psi)	640	690	980
Durometer, Shore A (pts)	74	72	84
Compression Set	18	17	26
(ASTM D395, Method B, 70 hrs. @ 200°C)			
Rheological Properties			
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.			
177°C (350°F)			
ML (in-lbs)	0.8	1.5	1.7
ts2 (min)	2.2	1.4	1.3
t'50 (min)	2.8	1.8	1.6
t'90 (min)	4.5	2.7	2.0
MH (in-lbs)	15.3	4	26.6
200°C (392°F)			
ML (in-lbs)	0.6	1.2	1.7
ts2	0.7	0.6	0.4
t'50	0.9	0.7	0.5
t'90	1.3	0.9	0.6
MH (in-lbs)	13.1	16.0	24.0

* Incorporated cure polymer

MOLDED GOOD APPLICATIONS
Dyneon

	1	2	3	4
Fluorel™ FC-2122*	100			
Fluorel FC-2123*		100		
Fluorel FC-2144*			100	
Fluorel FC-2152*				100
MT Black (N990)	30	30	30	30
MgO	3	3	3	3
$Ca(OH)_2$	6	6	6	6

Physical Properties
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C

	1	2	3	4
%F	65.9	65.9	65.9	65.9
S.G.	1.80	1.80	1.80	1.80
Mooney Visc. (1+10) @ 121°C	25	25	41	51
TR 10 (°C)	-18	-18	-18	-18
Tensile (psi)	1900	2350	2540	2100
Elongation (%)	310	270	260	305
M100 (psi)	520	530	550	550
Durometer, Shore A (pts)	75	71	70	73
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	25	20	17	22

Rheological Properties
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.

	1	2	3	4
177°C (350°F)				
ML (in-lbs)	0.9	0.9	1.5	2.2
ts2 (min)	1.2	1.2	0.9	1.0
t'50 (min)	1.4	1.6	1.2	1.3
t'90 (min)	2.1	2.8	1.9	1.8
MH (in-lbs)	12.1	12.2	15.2	15.6
200°C (392°F)				
ML (in-lbs)	0.8	0.7		
ts2	0.5	0.5		
t'50	0.6	0.6		
t'90	0.8	1.2		
MH (in-lbs)	9.4	10.1		

* Incorporated cure polymer

MOLDED GOOD APPLICATIONS
Dyneon

	5	6	7	8
Fluorel™ FC-2176*	100			
Fluorel FC-2177*		100		
Fluorel FC-2181*			100	
Fluorel FLS-2530*				100
MT Black (N990)	30	30	30	30
MgO	3	3	3	3
$Ca(OH)_2$	6	6	6	6
Physical Properties				
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C				
%F	65.9	65.9	65.9	69.0
S.G.	1.80	1.80	1.80	1.85
Mooney Visc. (1+10) @ 121°C	30	33	44	38
TR 10 (°C)	-18	-18	-18	-8
Tensile (psi)	2175	1865	2560	2200
Elongation (%)	240	240	240	255
M100 (psi)	600	700	690	700
Durometer, Shore A (pts)	71	75	72	77
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	22	21	13	19
Rheological Properties				
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.				
177°C (350°F)				
ML (in-lbs)	1.1	1.6	1.6	1.4
ts2 (min)	1.1	1.8	1.0	1.5
t'50 (min)	1.3	2.5	1.2	1.9
t'90 (min)	2.0	4.3	1.7	2.6
MH (in-lbs)	14.5	15.1	18.5	20.2
200°C (392°F)				
ML (in-lbs)				
ts2				
t'50				
t'90				
MH (in-lbs)				

* Incorporated cure polymer

FLUOROELASTOMER MOLDED GOODS
Ausimont

Tecnoflon FOR 5351/U	100
Magnesium Oxide (High Activity)	3
Calcium Hydroxide	6
MT N-990 Carbon Black	30
Physical Properties	
Press Cure 10 minutes @ 170°C	
Post Cure 8 hours + 16 hours @ 250°C	
Hardness, Shore A, points	75
Tensile Strength, psi	2322
Elongation, %	240
100% Modulus, psi	653
Compression Set (-214 O-rings) 20 hours @ 200°C, %	18

INJECTION MOLDABLE

DuPont Dow

Viton A-200	97.5
Calcium Hydroxide	6
N990	30
Maglite D	3
VPA #3	1
Viton Curative #50	2.5
Total	**140**
Expected Physical Properties – Original	
Tensile Strength, psi	1800
Elongation, %	190
Hardness, Shore A	77
Compression Set	
70 hours @ 200°C, %	12

CALENDERING COMPOUND

DuPont Dow

Viton B-600	96.3
Calcium Hydroxide	6
N990	30
Maglite D	3
Carnuba Wax	1
Viton Curative #20	2.5
Viton Curative #50	1.2
Total	**140**
Expected Physical Properties – Original	
Tensile Strength, psi	1835
Elongation, %	225
Hardness, Shore A	71
Compression Set	
70 hours @ 100°C, %	31

LOW HARDNESS FLUOROELASTOMER ARTICLES

Ausimont

Tecnoflon FOR LHF	100
Magnesium Oxide (High Activity)	1.5
Calcium Hydroxide	1.5
Barium Sulfate	5.0
Physical Properties	
Press Cure 10 minutes @ 170°C	
Post Cure 8 hours + 16 hours @ 250°C	
Hardness Shore A, points	45
Tensile Strength, psi	725
Elongation, %	360
100% Modulus, psi	145
Brittle Point, °C	-40
Compression Set (-214 O-rings) 70 hours @ 200°C, %	15
Heat Aging (168 hours @ 250°C)	
Hardness Change, points	-2
Tensile Change, %	+5
Elongation Change, %	+25
Chemical Resistance	
Immersion 168 hours @ 23°C	
Reference Fuel C	
Volume Change, %	+5

NO POSTCURE FLUOROELASTOMER ARTICLES
Ausimont

	1	2
Tecnoflon P757	100	----
Tecnoflon P959	----	100
Luperco 101XL	3	3
TAIC, 75% Dispersion	4	4
Zinc Oxide	5	5
MT N-990 Carbon Black	30	30
Physical Properties		
Press Cure 10 minutes @ 170°C		
Hardness, Shore A (points)	67	71
Tensile Strength, psi	2354	2454
Elongation, %	320	259
100% Modulus, psi	462	650
Compression Set (-214 O- rings) 70 hours @ 200°C		
Press Cure 10 minutes @ 170°C, %	33	29
Chemical Resistance		
Immersion 168 hours @ 150°C		
Press Cure 10 minutes @ 170°C		
SH Motor Oil		
Hardness Change, points	+2.5	+5
Tensile Change, %	+8	+7
Elongation Change, %	+2	-3
Volume Change, %	-0.7	-0.6
Engine Coolants		
Hardness Change, points	+0.1	-0.5
Tensile Change, %	-11	+4
Elongation Change, %	-9	-1
Volume Change, %	+3	+3
ATF		
Hardness Change, points	+2.7	+2.2
Tensile Change, %	-8	-3
Elongation Change, %	-9	+2
Volume Change, %	+0.1	-0.1
Synthetic Gear Oil		
Hardness Change, points	+0.7	+0.4
Tensile Change, %	+1	+17
Elongation Change, %	-3	+9
Volume Change, %	+1.2	+0.2

LOW TEMPERATURE
DuPont Dow

Viton GLT	100
Calcium Hydroxide	3
N990	30
VPA #3	1
DIAK #8	0.8
RC-R-6156	0.2
Lupercol 101XL	3
Total	**138**
Expected Physical Properties – Original	
Tensile Strength, psi	2540
Elongation, %	180
Hardness, Shore A	70
Compression Set	
70 hours @ 150°C, %	22

FOOD GRADE APPLICATIONS

Dyneon

Recipe	1	2
Fluorel™ FG-5630Q	100	
Fluorel FG-5690Q		100
MT Black (N990)	30	30
MgO	3	3
$Ca(OH)_2$	6	6

Physical Properties
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C

%F	65.9	65.0
S.G.	1.80	1.80
Mooney Visc. (1+10) @ 121°C	30	90
TR 10 (°C)	-18	-18
Tensile (psi)	2140	2220
Elongation (%)	210	205
M100 (psi)	810	955
Durometer, Shore A (pts)	77	76
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	13	10

Rheological Properties
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.

177°C (350°F)		
ML (in-lbs)	0.9	3.6
ts2 (min)	1.7	1.6
t'50 (min)	2.0	2.6
t'90 (min)	2.8	3.5
MH (in-lbs)	21.5	26.0
200°C (392°F)		
ML (in-lbs)		
ts2		
t'50		
t'90		
MH (in-lbs)		

FABRIC COMPOSITE/CALENDERED SHEET APPLICATIONS

Dyneon

Recipe	**1**	**2**
Fluorel™ FC-2120	100	
Fluorel FT-2350		100
MT Black (N990)	30	30
MgO	3	3
$Ca(OH)_2$	6	6
Physical Properties		
Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C		
%F	65.9	68.6
S.G.	1.80	1.80
Mooney Visc. (1+10) @ 121°C	23	56
TR 10 (°C)	-18	-14
Tensile (psi)	2140	2210
Elongation (%)	200	310
M100 (psi)	850	540
Durometer, Shore A (pts)	75	75
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	16	36
Rheological Properties		
Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.		
177°C (350°F)		
ML (in-lbs)	0.9	2.8
ts2 (min)	1.3	0.9
t'50 (min)	1.6	1.2
t'90 (min)	2.4	1.7
MH (in-lbs)	20.0	15.8
200°C (392°F)		
ML (in-lbs)		
ts2		
t'50		
t'90		
MH (in-lbs)		

AGGRESSIVE OIL/COOLANT/BASE RESISTANT APPLICATIONS
Dyneon

Fluorel™ II FX-11900*	100
MT Black (N990)	30
MgO	3
$Ca(OH)_2$	6

Physical Properties Press cure 10 min. @ 177°C, Post cure 24 hrs. @ 260°C	
%F	59.0
S.G.	1.60
Mooney Visc. (1+10) @ 121°C	32
TR 10 (°C)	-14
Tensile (psi)	2270
Elongation (%)	220
M100 (psi)	850
Durometer, Shore A (pts)	74
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	43

Rheological Properties Monsanto MDR 2000™, 100 cpm, 0.5° arc, 6 min.	
177°C (350°F)	
ML (in-lbs)	1.3
ts2 (min)	1.7
t'50 (min)	1.9
t'90 (min)	3.1
MH (in-lbs)	13.0
200°C (392°F)	
ML (in-lbs)	
ts2	
t'50	
t'90	
MH (in-lbs)	

*Incorporated cure polymer

AGGRESSIVE OIL/COOLANT/BASE RESISTANT APPLICATIONS
Dyneon

	1	2	3	4	5
Aflas™ TFE FA-150L	100				
Aflas TFE FA-150E		100			
Aflas TFE FA-150P			100		
Aflas TFE FA-100S				100	
Aflas TFE FA-100H					100
MT Black (N990)	25	25	25	25	25
Triallyl isocyanurate (TAIC)	5	5	5	5	5
Percadox™ 14	1	1	1	1	1
Sodium Stearate	1	1	1	1	1
Physical Properties					
Press cure 10 min. @ 177°C, Post cure 16 hrs. @ 200°C					
%F	57.0	57.0	57.0	57.0	57.0
S.G.	1.55	1.55	1.55	1.55	1.55
Mooney Visc. (1+10) @ 100°C	35	60	95	160	110
TR 10 (°C)	+2	+2	+2	+3	+3
Tensile (psi)	1610	1905	2335	2965	2755
Elongation (%)	350	370	350	330	375
M100 (psi)	425	390	435	480	405
Durometer, Shore A (pts)	70	70	71	71	71
Compression Set (ASTM D395, Method B, 70 hrs. @ 200°C)	42	48	44	44	50
Rheological Properties					
Monsanto ODR @ 177°C, 100 cpm, 3.0° arc, microdie, 12 min.					
177°C (350°F)					
ML (in-lbs)	2.9	6.0	13.4	24.0	33.5
ts2 (min)	1.9	1.8	1.6	1.5	1.4
t'50 (min)	3.9	3.7	3.2	2.8	2.6
t'90 (min)	8.7	8.4	7.6	7.0	6.2
MH (in-lbs)	38.6	46.9	63.8	82.5	80.4
200°C (392°F)					
ML (in-lbs)					
ts2					
t'50					
t'90					
MH (in-lbs)					

SILICONE SPONGE
Uniroyal

	1	2	3
Oven or Press Molded			
Silicone Gum*	100.0	100.0	100.0
Dicup 40KE	2.5	----	----
Vulcup 40KE	----	2.5	----
Varox DBPH-50	----	----	2.5
Celogen 780	4.0	4.0	4.0
Cellite Super Floss	3.0	3.0	3.0
Total	**109.5**	**109.5**	**109.5**
Samples Cured 15 mnutes @ 177°C(350°F)			
Density, lbs/ft^3	43	40	37
Density, kg/m^3	688	640	592
25% Compression Deflection			
psi	17	18	18
kPa	117	124	124
50% Compression Set			
22 Hours @ 93°C(200°F)	15	4	6
Aged, Change in Compression			
95 hours @ 204°C(400°F), %	+13	-0.5	-2

*Dow Corning GP-30 GE SE488

X.

Acrylate Epichlorohydrin

ECO HIGH TEMPERATURE HOSE

Zeon

	1	2	3	4
Hy Temp AR-715	100.00	100.00	80.00	60.00
Hy Temp AR-74	----	----	20.00	40.00
Stearic Acid	1.00	1.00	1.00	1.00
Naugard 445	2.00	2.00	2.00	2.00
Struktol WB222	2.00	2.00	2.00	2.00
TP-759	----	5.00	----	----
Vulcan 5H	55.00	55.00	55.00	55.00
Vulkalent E/C	0.30	0.30	0.30	0.30
Hy Temp ZC-50	5.00	5.00	5.00	5.00
Total	**165.30**	**170.30**	**165.30**	**165.30**
Processing Properties				
Mooney Viscometer				
ML (1+4) @ 100°C	67	54	64	59
ML (1+35) @ 125°C	54	44	51	46
T5, mins.	12.7	14.5	14.6	15.8
Rheometer, 100 CPM, 3° Arc, 190°C				
ML, lb-in	10.2	8.8	9.8	9.2
MH, lb-in	55	48.4	52.2	49.2
Ts2, mins.	2.1	2.4	2.4	2.4
T90, mins.	8.9	9.7	9	9
Original Physicals, Cured 4 mins. @ 190°C				
100% Modulus, MPa	2.8	2.1	3.1	2.4
100% Modulus, psi	400	300	450	345
200% Modulus, MPa	6.7	5.1	7.3	5.9
200% Modulus, psi	970	735	1060	855
Tensile Strength, MPa	11.0	10.4	11.2	9.9
Tensile Strength, psi	1600	1510	1630	1430
Elongation, %	370	465	345	380
Hardness, Shore A	66	60	67	64

HIGH TEMPERATURE HOSE
Continued

Post Cured Physicals, Post Cured 4 Hrs. @ 180°C				
100% Modulus, MPa	4.8	3.8	4.8	4.2
100% Modulus, psi	7000	545	695	605
200% Modulus, MPa	10.5	8.5	10.4	9.3
200% Modulus, psi	1520	1230	1510	1350
Tensile Strength, MPa	11.5	10.7	11.0	10.3
Tensile Strength, psi	1665	1555	1590	1500
Elongation, %	230	265	210	230
Hardness, Shore A	71	71	72	71
Compression Set, Post Cured, Buttons, Aged 70 Hrs. @ 150°C				
Set, %	24	26	24	28
Tear, Die “C”, ppi	147	138	137	140
Tear, Die “C”, kN/m	25.7	24.2	24.0	24.5
Gehman Low Temperature Torsion				
Original Angle, °	157	163	163	166
T2, °C	-5	-5	-2.1	-5
T5, °C	-11.2	-15.2	-12.5	-14.7
T10, °C	-15.5	-18.8	-16.6	-18.1
T100, °C	-23.3	-28	-25.8	-28.1
Aged: Air Oven, 70 Hrs. @ 175°C				
Tensile Strength	1425	1275	1340	1275
% Change	-14%	-18%	-16%	-15%
Elongation	260	285	245	230
% Change	13%	8%	17%	0%
Hardness	81	80	78	79
Points Change	10	9	6	8

HIGH TEMPERATURE HOSE
Continued

Aged: Air Oven, 168 Hrs. @ 175°C				
Tensile Strength	1145	1055	1115	995
% Change	-31%	-32%	-30%	-34%
Elongation	225	245	220	200
% Change	-2%	-8%	5%	-13%
Hardness	82	83	81	80
Points Change	11	12	9	9
Aged: Air Oven, 500 Hrs. @ 175°C				
Tensile Strength	995	905	1025	950
% Change	-40%	-42%	-36%	-37%
Elongation	190	180	155	125
% Change	-17%	-32%	-26%	-46%
Hardness	89	90	88	87
Points Change	18	19	16	16
Aged: IRM 903 Oil, 70 Hrs. @ 150°C				
Tensile Strength	1500	1500	1400	1310
% Change	-19%	-4%	-12%	-13%
Elongation	195	225	195	195
% Change	-15%	-15%	-7%	-15%
Hardness	60	57	55	51
Points Change	-11	-14	-17	-20
Volume Change, %	18	16	20	22

HOSE FORMULAS
Zeon

	1	2	3
Nipol AR-72HF	100.00	75.00	----
Nipol AR-74	----	25.00	----
Hy Temp AR-72LF	----	----	100.00
Stearic Acid	1.00	1.00	1.00
Struktol WB222	2.00	2.00	2.00
Naugard 445	2.00	2.00	2.00
N-330 Black	40.00	40.00	40.00
N-550 Black	40.00	30.00	40.00
TP-759	8.00	----	8.00
Vulkalent E/C	0.30	0.30	0.30
Hy Temp ZC-50	5.00	5.00	5.00
Total	**198.30**	**180.30**	**198.30**
Processing Properties			
Mooney Viscometer			
ML(1+4) @ 100°C	51	56	45
ML(1+35) @ 125°C	42	46	36
T5, mins.	25.2	23.9	28.6
T35, mins.			
Rheometer, 100 CPM, 3° Arc, 190°C			
ML, lb-in	16.5	10.9	11.3
MH, lb-in	57.5	53.1	56.2
Ts2, min.	2.6	2.5	2.2
T90, min.	11	10.7	9.1
Cure Time, mins.	4	4	4
Original Physicals, Cured 4 mins @ 190°C			
100% Modulus, MPa(psi)	2.8(401)	4.0(583)	3.2(465)
200% Modulus, MPa(psi)	6.1(882)	8.5(1233)	6.4(935)
Tensile Strength, MPa(psi)	8.8(1271)	11.1(1616)	8.3(1208)
Elongation, %	418	351	348
Hardness, Shore A	64	61	66
Post Cured Physicals, Post Cured 4 Hrs. @ 180°C			
100% Modulus, MPa(psi)	3.6(521)	4.8(700)	4.7(676)
200% Modulus, MPa(psi)	8.1(1178)	10.3(1500)	9.2(1340)
Tensile Strength, MPa(psi)	9.9(1434)	12.1(1758)	9.9(1440)
Elongation, %	310	281	248
Hardness, Shore A	68	67	70

HOSE FORMULAS
Continued

Compression Set, Post Cured, Buttons, Aged 70 Hrs. @ 150°C			
Set, %	18	24	27
Tear, Die "T", ppi	26	21.6	22.8
Tear, Die "T", kN/m	4.6	3.8	4.0
Gehman Low Temperature Torsion			
Original Angle, °	168	169	168
T2, °C	-2.5	-0.3	-2.5
T5, °C	-16.4	-14.4	-19.4
T10, °C	-22.7	-20.7	-23.9
T100, °C	-33.7	-30.3	-34
Aged: Air Oven, 168 Hrs. @ 150°C			
Tensile Strength (% Change)	1465(2%)	1764(0%)	1423(-1%)
Elongation (% Change)	244(-21%)	246(-12%)	184(-26%)
Hardness (Points Change)	80(12)	76(9)	80(10)
Aged: Diesel Fuel, 46 Hrs. @ 23°C			
Tensile Strength (% Change)	1482(3%)	1530(-13%)	1455(1%)
Elongation (% Change)	268(-14%)	249(-11%)	261(5%)
Hardness (Points Change)	57(-11)	56(-11)	57(-13)
Volume Change, %	9	11	9
Aged: BP 4437 Motor Oil, 94 Hrs. @ 150°C			
Tensile Strength (% Change)	1732(21%)	1841(5%)	1702(18%)
Elongation (% Change)	271(-13%)	231(-18%)	256(3%)
Hardness (Points Change)	66(-2)	64(-3)	66(-4)
Volume Change, %	0	4	0

ACRYLATE SEAL COMPOUND
R.T. Vanderbilt

Cyanacryl R	100.0
Stearic Acid	2.0
FEF Black (N-550)	60.0
AGERITE SUPERFLEX	2.0
Sodium Stearate	3.0
Potassium Stearate	0.5
Spider Sulfur	0.3
Total	167.8
Physical Properties	
Tensile, MPa (psi)	11.9(1730)
100% Modulus, MPa (psi)	4.6(670)
Elongation, %	270
Hardness, Shore A	71

ACRYLATE SEAL COMPOUND

R.T. Vanderbilt

Vamac G	100.0
Stearic Acid	1.0
Armeen 18D	0.5
VANFRE VAM	2.0
FEF Black (N-550)	60.0
Graphite	20.0
Dioctyl Phthalate (DOP)	10.0
VANOX ZMTI	2.0
VANOX AM	1.0
VANAX DOTG	4.0
DIAK No. 1	1.25
Total	201.75
Physical Properties	
Tensile, MPa (psi)	15.0(2180)
100% Modulus, MPa (psi)	5.5(800)
Elongation, %	240
Hardness, Shore A	72

HIGH HEAT SERVICE WIRE INSULATION OR CABLE JACKET
Zeon

	1	2	3
HyTemp 4051EP	100	----	50
HyTemp 4054	----	100	50
Stearic Acid	1	1	1
ZO-9	6	6	6
Nulok 321	90	120	105
Zeolex 23	45	60	53
Admex 760	15	15	15
Agerite Stalite S	2	2	2
Cumate	0.2	0.2	0.2
PE617	6	6	6
Vanax 829	0.9	0.9	0.9
Butyl Tuads	2.5	2.5	2.5
Lead Stearate	0.5	0.5	0.5
TOTAL	**269.1**	**314.1**	**292.1**
Volume Resistivity			
Ohm-CM X 10^{10}	23.7	7.2	14.7
Air Oven – 70 Hrs./150°C			
Tensile Strength,psi	1020	720	840
Tensile Change, %	+31	+57	+45
Elongation, %	220	140	150
Elongation Change, %	-46	-60	-44
Hardness, Duro A	76	75	76
Hardness Change, pts	+13	+15	+13
180° Bend	Pass	Pass	Pass
Air Oven – 70 Hrs./175°C			
Tensile Strength,psi	1400	1000	1150
Tensile Change, %	+79	+117	+98
Elongation, %	120	80	80
Elongation Change, %	-71	-73	-70
Hardness, Duro A	81	81	82
Hardness Change, pts	+18	+21	+19
180° Bend	Pass	Pass	Pass

HIGH HEAT SERVICE WIRE INSULATION OR CABLE JACKET Continued

AIR OVEN – 70 HRS./190°C			
Tensile Strength,psi	1420	----	940
Tensile Change, %	+82	----	+62
Elongation, %	80	----	50
Elongation Change, %	-80	----	-81
Hardness, Duro A	83	----	85
Hardness Change, pts	+20	----	+22
180° Bend	Pass	----	Pass
ASTM OIL NO. 3 - 70 HRS./150°C			
Tensile Strength,psi	1040	470	740
Tensile Change, %	+33	+2	+28
Elongation, %	150	100	100
Elongation Change, %	-63	-71	-63
Hardness, Duro A	57	33	44
Hardness Change (%)	-6	-27	-19
Volume Change (%)	+20	+62	+36
180° Bend	Pass	Pass	Pass
Det. Specific Gravity	1.520	1.559	1.546
Garvey Die Extrusion/110°C – 30 RPM			
In/min.	84	84	81
Gms/min.	218	220	184
Gms/in.	2.60	2.62	2.27
Edge	4	4	4
Surface	4	4	4
Corners	4	4	4
Swell	3-1/2	3-1/2	3-1/2
	15-1/2	15-1/2	15-1/2
Mooney Viscometer/125°C – Large Rotor			
MV	25	33	28
T5(min.)	12	7-1/2	8-3/4
T35(min.)	18-1/2	11-3/4	14-1/2
Monsanto Rheometer at 163°C/204°C – Micro Die, 1° Arc, 100 CPM			
ML	3.7/3.7	6.2/6.6	4.9/4.1
Ts1(min.)	2.4/0.8	2.3/0.6	2.4/0.7
T'90(min.)	9.7/2.6	10.0/2.4	9.7/2.5
MHF	17.7/18.7	15.2/15.2	16.2/15.9

HIGH HEAT SERVICE WIRE INSULATION OR CABLE JACKET Continued

Original Properties – Mold Cured 15’ @ 163°C/2’ @ 204°C			
Stress/100% (psi)	480/500	340/360	460/460
Tensile Strength (psi)	780/780	460/460	580/580
Elongation (%)	380/410	300/350	250/270
Hardness (Duro A)	63/63	61/60	64/63
Following on 2’/204°C Mold Cures			
Compression Set – 22 Hrs./150°C			
Plied (%)	71	84	82
Gehman Low Temp. Flex			
T2(°C)	-2.5	-11	-5
T5(°C)	-11.5	-22	-14
T10(°C)	-14	-27.5	-17
T100(°C)	-19	-37	-25
Dielectric Strength			
Volts/mil	322	283	309

FUEL HOSE

Zeon

		GM 6289M SAE J30 (30 R7)
Hydrin C2000	75.0	
Hydrin H	25.0	
Chlorobutyl 1068	10.0	
N-330	80.0	
DIDP	15.0	
Paraplex G-50	15.0	
Vulkanox MB-2/MG/C	1.0	
Stearic Acid	1.0	
Calcium Carbonate	5.0	
Zisnet F-PT	0.6	
DPG	0.7	
Total	**228.3**	
Mooney 1+4 100°C, minimum	72	
Mooney Scorch, 1+30 minutes @ 125°C		
Maximum	168	
Minimum	68	
T5, minutes	3.0	
T35, minutes	6.2	
Rheometer, 30 minutes @ 190°C		
MH'lbf.in.	42	
ML'lbf.in.	13	
Ts2, minutes	1.5	
T'90, minutes	24.6	
Originals, Cured 25 minutes @ 190°C		
100% Modulus, psi	560	
Tensile Strength, psi	1630	1200(8.3)
Elongation, %	300	200(225)
Hardness, Shore A, poitns	69	(tube)
Air Oven, Aged 70 Hrs. @ 125°C		
100% Modulus, psi (change, %)	1000(79)	
Tensile Strength, psi (change, %)	1580(-3)	
Elongation, % (change, %)	170(-43)	
Hardness, Shore A, pts.(change,pts)	80(11)	
180° Bend		
Ozone, GM4486P & ASTM D518, 168 hours @ 100 pphm, 38°C, 20% Elongation, 2X		

FUEL HOSE
Continued

IRM 903 Oil, Aged 70 Hrs. @ 125°C		
100% Modulus, psi (change, %)	750(34)	
Tensile Strength, psi (change, %)	1720(6)	6.6(957)
Elongation, % (change, %)	250(-17)	150(-40)
Hardness, Shore A, pts. (change, pts)	68(-1)	
Volume Change, %	5	O to +6(5 to +15)
Weight Change, %	3	tube
Fuel C, Aged 48 Hrs. @ 23°C		
100% Modulus, psi(change, %)	510(-9)	
Tensile Stength, psi (change, %)	900(-45)	
Elongation, % (change, %)	170(-43)	
Hardness, Shore A, pts.(change, pts)	46(-23)	
Volume Change, %	38	O to +60
Low Temperature flex, 70 hours @ -40C within 4 seconds between flat plates	Pass	No cracks

FUEL HOSE COVER

Zeon

Hydrin C2000L	100.0
N-762	85.0
Paraplex G-57	5.0
DIDP	15.0
Stearic Acid	1.0
Vulkanox MB-2/MG/C	1.5
Calcium Carbonate	5.0
Zisnet F-PT	0.5
DPG	0.5
Santogard PVI	0.5
Total	**214.0**
Mooney ML 1+4 @ 100°C	63
Mooney Scorch, Large Rotor, 125°C	
Maximum	128
Minimum	52
T5, minutes	8.7
T35, minutes	18.9
Rheometer, 20 minutes @ 190°C	
MH’lbf.in.	56
ML’lbf.in.	13
Ts2, minutes	2.0
T’90, minutes	15.2
Originals, Cured 20 minutes @ 190°C	
100% Modulus, psi	480
Tensile Strength, psi	1370
Elongation, %	260
Hardness, Shore A, points	59
Tear Strength, min, Die C, kN/m	35
Compression Set, % 70 Hrs. @ 125°C	53
Ozone Resistance 70 Hrs. @ 50 pphm, 40°C	Pass
Heat Aged 168 Hours @ 150°C	
100% Modulus, psi (delta, %)	660(38)
Tensile Strength, psi (delta, %)	830(-39)
Elongation, % (delta, %)	130(-50)
Hardness, Shore A, points (delta, points)	76(17)
180° Bend Test	Did not break

**FUEL HOSE COVER
Continued**

Fuel C, Aged 70 Hours @ 23°C	
100% Modulus, psi (delta, %)	430(-10)
Tensile Strength, psi (delta, %)	920(-33)
Elongation, % (delta, %)	190(-27)
Hardness, Shore A, points (delta, points)	44(-15)
Volume Swell, %	22
Visual Evaluaton – no surface tackiness	Pass
or cracks when folded flat against itself	Pass
Fuel C/15% Methanol, Aged 70 Hours @ 23°C	
100% Modulus, psi (delta, %)	420(-13)
Tensile Strength, psi (delta, %)	440(-69)
Elongation, % (delta, %)	90(-65)
Hardness, Shore A, points (delta, points)	40(-19)
Volume Swell, %	74
Visual Evaluaton – no surface tackiness	Pass
or cracks when folded flat against itself	Pass
Fuel C/10% Ethanol, Aged 70 Hours @ 23°C (ISO 1817/ASTM D471, 70 Hrs. @ 23 +/- 2 Methanol	
100% Modulus, psi (delta, %)	420(-13)
Tensile Strength, psi (delta, %)	640(-53)
Elongation, % (delta, %)	140(-46)
Hardness, Shore A, points (delta, points)	38(-21)
Volume Swell, %	77

ECO SEAL COMPOUND
R.T. Vanderbilt

Hydrin T	100.0
Stearic Acid	1.0
Dyphos	2.0
VANOX NBC	1.5
FEF Black (N-550)	45.0
HAF Black (N-326)	20.0
Plasticizer TP-95	5.0
VANFRE AP-2	1.0
SR-350	2.5
VAROX DCP-40C	1.75
Total	179.75
Physical Properties	
Tensile, MPa (psi)	11.3(1640)
100% Modulus, MPa (psi)	2.1(300)
Elongation, %	430
Hardness, Shore A	64

TRANSMISSION FLUID FILLER TUBE SEAL
S.A.E. J200 DH715 A26 B16 E36 ZI-Z5
Zeon

			Specification
Hydrin C2000	100.0	100.0	
N-330	50.0	---	
N-762	----	75.0	
TP-95	5.0	---	
Paraplex G-50	----	5.0	
Methyl Niclate	0.5	---	
Vulkanox MB-2/MG/C	0.5	1.0	
Span 60	1.0	1.0	
Calcium Carbonate	5.0	5.0	
Magnesium Oxide	3.0	3.0	
Zisnet F-PT	1.0	1.0	
Santogard PVI	0.7	1.0	
DPG	---	0.3	
Total	**166.7**	**192.3**	
Mooney ML 1+4 @ 100°C	121	---	
Mooney Scorch, Large Rotor, 125°C			
Minimum	98	103	
Maximum	173	204	
T5, minutes	9.1	2.7	
T35, minutes	22.0	4.9	
Rheometer, 15 minutes @ 200°C			
MH'lbf.in.	100	113	
ML'lbf.in.	20	26	
Ts2, minutes	1.2	0.8	
T'90, minutes	8.6	8.2	
Originals, Cured 15 minutes @ 200°C			
100% Modulu, psi	750	1110	
Tensile Strength, psi	2290	1760	1500
Elongation, %	350	170	250
Hardness, Shore A, pts.	73	76	65-75
Graves Tear, Die C, ppi	270	150	150
Comp. Set, % 22 Hrs @ 150°C, Discs	56*	52*	25

TRANSMISSION FLUID FILLER TUBE SEAL
S.A.E. J200 DH715 A26 B16 E36 ZI-Z5
Continued

ASTM Brittleness 5 Hrs. @ -40°C	-39*	-33*	-40 C when OD compressed 50%
Ozone, 72 Hrs. @ 100 pphm @ 38°C, 20% Elongation	No cracking	No cracking	
Air Test Tube, Aged 70 Hrs. @ 150°C			
100% Modulus, psi(%)	1050(40)	1240(12)	
Tensile Strength, psi(%)	1960(-14)	1240(-30)	-30
Elongation, % (%)	190(-46)	100(-41)	-60
Hardness, Shore A, pts(pts)	83(10)	81(5)	+15
ASTM No. 3, Aged 70 Hrs. @ 150°C			
100% Modulus, psi (%)	950(27)	1480(33)	
Tensile Strength,psi(%)	2080(-9)	1790(2)	
Elongation, % (delta,%)	210(-40)	130(-24)	
Hardness,Shore A, pts(pts)	73(0)	77(1)	125°C
Volume Swell, %	9	7	+30
Weight Change, %	6	4	
ATF Dexron II, Aged 70 Hrs. @ 150°C			
Tensile Strength,psi(%)	1260(-45)	1050(-40)	
Elongation, %(delta,%)	90(-74)	50(-71)	
Hardness,Shore A,pts.(pts.)	81(8)	87(11)	-5 to +10
Volume Swell, %	1.1	1.3	+1 to +10
Weight Change, %	0.5	0.2	
Z5 – Color, Black	Pass	Pass	

FORMULAS FOR SMOOTH EXTRUSIONS
Zeon

	1	2	3
Hydrin H	100.0	100.0	100.0
N-330	20.0	20.0	20.0
N-990	100.0	100.0	100.0
DIDP	3.0	3.0	3.0
Vulkanox MB-2/MG/C	1.0	1.0	1.0
Stearic Acid	1.0	1.0	1.0
Calcium Carbonate	5.0	5.0	5.0
Magnesium Oxide	3.0	3.0	3.0
Calcium Hydroxide	---	---	1.0
Zisnet F-PT	0.5	0.5	0.5
DPG	0.5	1.0	1.0
Santogard PVI	0.2	0.2	0.2
Total	**234.2**	**234.7**	**235.7**
EXTRUSION	Not Run	Smooth	Smooth
Stock Temp., °C	---	110	111
Mix Time, seconds	---	391	324
Mooney Viscosity			
ML(1+4) @ 100°C	93	104	109
Mooney Scorch: ML (1+30) @ 125°C			
Viscosity, min.	71	81	84
t5, minutes	6.3	3.5	3.1
t35, minutes	13.3	6.3	5.7
ODR: 3°C @ 160°C for 60 minutes			
MH, lbf-in	69	103	111
ML, lbf-in..	18	21	21
ts2, minutes	2.6	2.1	2.2
t'90, minutes	25.6	33.7	37.3
Originals: Cured 60 Minutes @ 160°C			
Hardness (A), pts.	81	80	81
Stress 100%, psi	1510	1400	1510
Tensile, psi	1680	1610	1650
Elongation, %	130	150	140

FORMULA FOR LOW TEMPERATURE FLEXIBILITY

Zeon

Hydrin C2000L	100.0
N-550	75.0
TP-95	25.0
Vulkanox MB-2/MG/C	1.0
Stearic Acid	1.0
Calcium Carbonate	5.0
Magnesium Oxide	3.0
Zisnet F-PT	1.0
Total	**211.0**
Mooney ML 1+4, Large Rotor, 100°C	75
Mooney Scorch, Large Rotor, 125°C	
Minimum	57
T5, minutes	4.3
Rheometer, 3° Arc, 12 minutes @ 200°C	
MH'lbf.in.	77
ML'lbf.in.	8
Ts2, minutes	0.5
T'90, minutes	8.1
Originals, Cured 12 minutes @ 200°C	
100% Modulus, psi	1170
Tensile Strength, psi	1510
Elongation, %	130
Hardness, Shore A, points	81
Air Oven, Aged 72 Hours @ 125°C	
100% Modulus, psi (delta, %)	1480(26)
Tensile Strength, psi (delta, %)	1590(5)
Elongation, % (delta, %)	110(-15)
Hardness, Shore A, points (delta, pts.)	92(11)
ASTM No. 3 Oil, Aged 72 Hours @ 100°C	
100% Modulus, psi (delta, %)	1240(6)
Tensile Strength, psi (delta, %)	1650(9)
Elongation, % (delta, %)	150(15)
Hardness, Shore A, poitns (delta, pts.)	88(7)
Volume Change, %	-6
Weight Change, %	-5

FORMULA FOR LOW TEMPERATURE FLEXIBILITY Continued

Fuel C, Aged 48 Hours @ 23°C	
100% Modulus, psi (delta, %)	1020(-13)
Tensile Strength, psi (delta, %)	1310(-13)
Elongation, % (delta, %)	120(-8)
Hardness, Shore A, poitns (delta, pts.)	70(-11)
Volume Change, %	17
Weight Change, %	9
Retraction Temperature Analysis, C, 50% Elongation	
TR10	-50
TR30	-43
TR50	-39
TR70	-34
TR70-TR10	17
Gehman Cold Twist Test, C	
T2	-23
T5	-39
T10	-43
T100	-54
Freeze Point	-52

FORMULA FOR LOW WATER SWELL

Zeon

Hydrin H	40.0
Hydrin C2000	60.0
N-762	30.0
Cabosil M5	15.0
Paraplex G-57	2.0
Vulkanox MB-2/MG/C	1.0
Stearic Acid	1.0
Calcium Carbonate	3.0
Zisnet F-PT	0.5
DPG	0.5
Santogard PVI – to reduce viscosity	0.5
Total	**153.0**
Originals, Cured 12 minutes @ 200°C	
100% Modulus, psi	320
Tensile Strength, MPa, (psi)	15.4(2230)
Elongation, %	510
Hardness, Shore A, points	61
Tear, Die B	510
Low Temperature Tests, 22 Hours @ -40°C	
Hardness, Shore A	93
Mandrel Wrap, 180° Bend	Fail
Air Oven Aging, 94 Hours @ 150°C	
100% Modulus, (% Change)	580(81)
Tensile, psi, (% Change)	10.5(-32)
Elongation, % (% Change)	220(-57)
Hardness, Shore A Durometer (pts. Change)	67(6)
Water Aging, 10 Days @ 80°C	
100% Modulus, (% Change)	280(-13)
Tensile, psi, (% Change)	14.8(-4)
Elongation, % (% Change)	450(-12)
Hardness, Shore A Durometer (pts. Change)	54(-7)
Weight Change, %	4
Volume Change, %	6
Ozone Tests, 46 Hours, 50 pphm, 23°C, Elongation 30%	Pass

35 SHORE A COMPOUND
Zeon

Hydrin C2000	100.0
N-990	70.0
Paraplex G-50	15.0
DIDP	10.0
Vulkanox MB-2/MG/C	1.0
Stearic Acid	1.0
Calcium Carbonate	5.0
Zisnet F-PT	0.4
DPG	1.0
Total	**203.4**
Stock Temp., °C	107
Mix Time, seconds	241
Mooney Viscosity: ML (1+4) @ 100°C	4
Money Scorch: ML (1+30) 2 125°C	
Viscosity, min.	46
t5, minutes	4.1
t35, minutes	6.9
ODR: 3° Arc, 30 minutes @ 170°C	
MH, lbf-in	41
ML, lbf-in	14
ts2, minutes	1.0
t'90, minutes	14.1
ODR: 3° Arc, 12 minutes @ 177°C	
MH, lbf-in	35
ML, lbf-in	14
ts2, minutes	1.2
t'90, minutes	7.5
Originals: Cured 20 minutes @ 190°C	
Hardness (A), pts.	38
Stress 50%, psi	110
Stress 100%, psi	220
Stress 200%, psi	520
Stress 300%, psi	820
Tensile, psi	770
Elongation, %	300

50 DUROMETER COMPOUND
Zeon

Hydrin T3102	100.0
N-762 SRF	15.0
N-550 FEF	20.0
Paraplex G-50	15.0
NBC	1.5
Stearic Acid	1.0
Span 60	3.0
Mold Wiz EQ6	1.0
Magnesium Oxide (Maglite D)	3.0
Zisnet F-PT	1.1
Santogard PVI	1.0
Total	**161.6**
Mooney Viscosity, ML 1+4 100°C	38
Mooney Scorch, Large Rotor, 125°C	
Maximum	74
Minimum	34
T5, minutes	13.7
T35, minutes	27.1
ODR 30 minutes @ 170°C	
MH’lbf.in.	47
ML’lbf.in.	11
Ts2, minutes	3.6
T’90, minutes	21.3
ODR 15 minutes @ 200°C	
MH’lbf.in.	50
ML’lbf.in.	11
Ts2, minutes	1.6
T’90, minutes	7.3
Originals, Cured 30 minutes @ 160°C	
100% Modulus, psi	270
Tensile Strength, psi	1870
Elongation, %	540
Hardness, Shore A, points	51
Compression Set, % 22 Hrs. @ 125°C, plied disc	23

50 DUROMETER COMPOUND
Continued

ASTM D2137 Brittleness, Test, °C	-39
Air Oven, Aged 72 Hours @ 120°C	
100% Modulus, psi (delta, %)	300(11)
Tensile Strength, psi (delta, %)	1940(4)
Elongation, % (delta, %)	420(-22)
Hardness, Shore A, points (delta, pts.)	52(1)
ASTM #3 Oil, Aged 70 Hours @ 120°C	
100% Modulus, psi (delta, %)	280(4)
Tensile Strength, psi (delta, %)	1580(-16)
Elongation, % (delta, %)	360(-33)
Hardness, Shore A, points (delta, pts.)	44(-7)
Volume Change, %	5
Weight Change, %	3
Fuel D, Aged 48 Hours @ 23°C	
100% Modulus, psi (delta, %)	250(-7)
Tensile Strength, psi (delta, %)	630(-66)
Elongation, % (delta, %)	200(-63)
Hardness, Shore A, points (delta, pts.)	36(-15)
Volume Change, %	29
Weight Change, %	16
Ozone Resistance	
80 pphm @ 40° C for 48 hours	No cracks

60 DUROMETER COMPOUND
Zeon

Hydrin C2000	75.0
Hydrin H	25.0
N-330	30.0
Stearic Acid	1.0
Vulkanox MB-2/MG/C	1.0
Calcium Carbonate	5.0
Zisnet F-PT	0.8
Santogard PVI	0.3
SPG	0.3
Total	**138.4**
Mooney ML 1+4 @ 100°C	88
Scorch 1+30 @ 125°C	
Maximum value	152
Minimum value	75
Time at T5, min.	8.1
Time at T35, min.	19.2
Rheometer, 45 minutes @ 180°C	
Maximum value	82
Minimum value	24
Time at Ts2	2.4
Time at 90%	32.5
Originals, Cured 40 minutes @ 180°C	
100% Modulus, psi	410
Tensile Strength, psi	1750
Elongation, %	310
Hardness, Shore A, points	63
Graves Tear, Die C(lb.f-inch)	180
Buttons, Cured 25 Minutes @ 200°C	
Compression Set %, 72 Hrs. @ 100°C	12
Compression Set %, 1000 Hrs. @ 100°C	42
Buttons, Cured 25 minutes @ 200°C	
Compression Set %, 72 Hrs. @ 125°C	47

60 DUROMETER COMPOUND
Continued

Low Temperature Retraction, °C	
TR10	-36
TR30	-32
TR50	-29
TR70	-23
TR70-TR-10	13
Ozone Resistance, 96 Hrs. @ 80 pphm, 23°C	Pass
Lupke Rebound, Buttons – 15’ @ 200°C	27
Air Oven, Aged 72 Hours @ 100°C	
100% Modulus, psi (delta, %)	490(20)
Tensile Strength, (delta, %)	2080(19)
Elongation, % (delta, %)	310(0)
Hardness, Shore A, points (delta)	66(3)
Air Oven, Aged 1000 Hours @ 100°C	
100% Modulus, psi (delta, %)	610(49)
Tensile Strength, (delta, %)	1810(3)
Elongation, % (delta, %)	200(-35)
Hardness, Shore A, points (delta)	65(2)
ASTM No. 3 Oil, Aged 1000 Hours @ 125°C	
100% Modulus, psi (delta, %)	420(2)
Tensile Strength, (delta, %)	1120(-36)
Elongation, % (delta, %)	200(-35)
Hardness, Shore A, points (delta)	53(-10)
Volume Change, %	14
Weight Change, %	9
Fuel C, Aged 1000 Hours @ 23°C	
100% Modulus, psi (delta, %)	620(51)
Tensile Strength, (delta, %)	560(-68)
Elongation, % (delta, %)	110(-65)
Hardness, Shore A, points (delta)	49(-14)
Volume Change, %	45
Weight Change, %	28

60 DUROMETER COMPOUND
Continued

Akron Rubber Development Lab **Originals, Cured 12 minutes @ 200°C**	
100% Modulus, psi	390
Tensile Strength, MPa (psi)	1700
Elongation, %	300
Hardness, Shore A, points	62
Specific Gravity	1.41
Diesel Fuel, Aged 1000 Hrs. @ 55°C	
100% Modulus, psi (delta, %)	440(13)
Tensile Strength, (delta, %)	1550(-9)
Elongation, % (delta,%)	250(-17)
Hardness, Shore A, points (delta)	59(-3)
Volume Change, %	5
Weight Change, %	3

60 DURO COMPOUNDS
Zeon

	1	2	3	4	5
Hydrin C2000	100.0	100.0	100.0	100.0	100.0
N-220	35.0	----	----	----	----
N-330	----	35.0	----	----	----
N-550	----	----	40.0	----	----
N-762	----	----	----	50.0	----
N-990	----	----	----	----	75.0
TP-95	10.0	10.0	10.0	10.0	10.0
(VANOX MTI or)					
Vulkanox MB-2/MG/C	1.0	1.0	1.0	1.0	1.0
Stearic Acid	1.0	1.0	1.0	1.0	1.0
Calcium Carbonate	5.0	5.0	5.0	5.0	5.0
Magnesium Oxide	3.0	3.0	3.0	3.0	3.0
Zisnet F-PT	0.8	0.8	0.8	0.8	0.8
DPG	0.5	0.5	0.5	0.5	0.5
Santogard PVI	0.3	0.3	0.3	0.3	0.3
Total	**156.6**	**156.6**	**161.6**	**171.6**	**196.6**
Mooney ML 1+4	93	82	82	71	76
Mooney Scorch: ML (1+30) @ 125°C					
Viscosity, min.	84	73	70	59	67
t5, minutes	5.0	4.8	5.3	8.2	6.5
t35, minutes	8.8	7.6	8.5	14.7	10.0
MDR: 15 minutes @ 200°C					
ML, dN-m	2.4	2.2	2.1	1.8	2.0
ML(lbf-in)	2.7	2.5	2.4	2.0	2.3
MH, dN-m	11.9	11.6	13.2	10.5	13.8
MH, (lbf-in)	13.4	13.1	14.9	11.9	15.6
ts2, minutes	0.7	0.6	0.5	1.1	0.4
t'90, minutes	6.0	4.6	3.6	8.4	2.7
Tan delta, max,final	0.05	0.033	0.028	0.022	0.025

60 DURO COMPOUNDS
Continued

Originals: Cured for 15 minutes @ 200°C					
Hardness (A),pts.	60	59	61	58	62
Stress 50% MPa	1.3	1.2	1.5	1.2	1.4
Stress 50% (psi)	190	180	220	170	210
Stress 100% MPa	2.1	2.1	2.8	2.1	2.8
Stress 100% (psi)	310	310	410	310	400
Stress 200% MPa	4.6	4.8	6.6	5.0	6.0
Stress 200% (psi)	660	690	960	730	870
Stress 300% MPa	8.0	7.8	----	8.1	----
Stress 300% (psi)	1160	1130	----	1170	----
Tensile, MPa	14.3	11.2	9.2	9.5	6.4
Tensile, (psi)	2070	1620	1330	1380	930
Elongation, %	520	420	280	390	220
Tear Strength: Die B					
23°C, kN/m	95	70	65	61	42
23°C (ppi)	540	400	370	350	240
Tear Strength: Die C					
23°C, kN/m	46	37	32	35	21
23°C (ppi)	260	210	180	200	120

DUROMETER 70 COMPOUND FOR HEAT RESISTANCE
PPG

Hydrin 200		100.0
Hi-Sil EP		50.0
Silane A189		1.0
NBC		1.0
Release Agent		1.0
Zinc Stearate		1.0
Red Lead		5.0
Ethylene Thiourea		1.75
Total		160.75
OD Rheometer at 171°C		
T2		1.5 minutes
T90		20 minutes
Mooney Scorch @ 121°C; T5		7.3 minutes
Stress Strain Properties (Cure: 30’/171°C)	Original	Aged 70 hrs. At 150°C
Hardness	71	75
M100	810(5.6)	--
Tensile	2100(14.4)	2200(15.0)
Elongation	240	180
Die C Tear	190	200
Compression Set, 22 hrs./121°C		13%
PICO Abrasion Index		92%

Notes:

XI.

Specialty Rubbers

HEAT RESISTANT HOSE

Exxon

Exxpro MDX 93-4		100
N-330		55
Paraffinic Oil		5
PE AC 617		4
Stearic Acid		2
Zinc Oxide		1
Ethyl Zimate		1
TEG		2
DHT4A2		2
MDR Properties, 1/2° Arc, 180°C, 30’		
ML, dN.m		1.7
MH, dN.m		10.5
t’25, minutes		3.9
t’90, minutes		9.7
Physical Property Retention	Original	70 Hours @ 175°C
Hardness	57	64
100% Modulus, MPa	3.1	5.0
Tensile, MPa	14.9	13.3
Elongation, %	260	200
	70 Hours @ 100°C	70 Hours @ 175°C
Compression Set, %	18.2	37.4

HOSE LINER
R.T. Vanderbilt

FA Polysulfide	100.0
Zinc Oxide	10.0
N-774 Carbon Black	60.0
Stearic Acid	0.5
ALTAX	0.4
VANAX DPG	0.1
Ethylene Thiourea	0.1
Neoprene W Masterbatch	29.0
Neoprene W	100.0
Magnesium Oxide	4.0
N-774 Carbon Black	55.0
Stearic Acid	0.5
Zinc Oxide	4.0
Physical Properties, Cured 40 Min. at 148°C(298°F)	
Hardness, Shore A	74
300% Modulus, MPa (psi)	9.5(1380)
Tensile Strength, MPa (psi)	9.5(1380)
Elongation, %	300
Volume Change after 30 days at 27°C(80°F)	
ASTM Fuel A, %	20
ASTM Fuel D, %	4
Ethyl Acetate, %	24
Acetone, %	18
Methyl Ethyl Ketone, %	36
Methyl Isobutyl Ketone, %	28
Carbon Tetrachloride, %	60
Water, %	4

INNERLINER COMPOSITION FOR SEVERE SERVICE

Exxon

Exxpro MDX 89-4	100.0
N-660 Black	60.0
Paraffinic Oil	15.0
Stearic Acid	1.0
Zinc Oxide	2.0
Sulfur	1.0
MBTS	2.0
Mooney Viscosity, ML (1+4) @ 100°C	56
Scorch, 135°C, min. to 5 pt. Rise	22
Rheometer, 160°C, 3° Arc, 30 min., 1.67 Hz, 0 Preheat	
ML, dN.m	11
MH, dN.m	24
ts2, min.	5
t'90, min.	13
Physical Properties Cured t'90 + 2 min. @ 160°C	
Hardness, Shore A	40
300% Modulus, MPa	2.9
Tensile Strength, MPa	8.9
Elongation, %	950
Fatigue-to-failure, kcyc ave 8 samples	660
Aged 3 Days @ 125°C	
Hardness, Shore A	50
300% Modulus, MPa	4.7
Tensile Strength, MPa	10.4
Elongation, %	760
Fatigue-to-failure, kcyc ave 8 samples	260
Aged 4 Weeks @ 100°C	
Hardness, Shore A	48
300% Modulus, MPa	5.6
Tensile Strength, MPa	11.0
Elongation, %	710
Fatigue-to-failure, kcyc ave 8 samples	199

TIRE CURING BLADDER
Exxon

Exxpro 3035		100.0
N-330		55.0
Castor Oil		7.0
Paraffin Wax		2.0
Perkalink 900		0.75
Zinc Oxide		3.0
SP1045		7.0
Stearic Acid		0.5
MBTS		1.2
DHT4A2		1.1
Magnesium Oxide		0.15
MS @ 150°C		
5 Pt. Rise, minutes		17.9
10 Pt. Rise, minutes		25.6
ML (1+4) @ 100°C		61.3
ODR Properties, 1° Arc, 190°C, 60 minutes		
ML, dN.m		5.3
MH, dN.m		13.0
t'25, minutes		4.4
t'90, minutes		10.2
Tension Set (300% Test @ Room Temperature)		15.1%
Physical Properties, Cured 12' @ 190°C	Original	48 Hours @ 177°C
Hardness	57	64
100% Modulus, MPa	3.1	5.0
Tensile, MPa	14.9	13.3
Elongation, %	260	200
	RT	150°C
Die B Tear, kN/m	46.6	19.8

NEW TIRE WHITE SIDEWALL COMPOSITION
Exxon

	Exxpro 3745/ NR* 60/40	Exxpro 3745/ NR* 50/50
TiO2	30	30
Nucap 290	32	32
Mistron Vapor Talc	34	34
Stearic Acid	1	1
Ultramarine Blue	0.2	0.2
Escorez 1102	4	4
Zinc Oxide	3	3
Zinc Stearate	1	1
Sulfur	0.2	0.2
Vultac #5	1.3	1.3
MBTS	1.3	1.3
Mooney Viscosity ML (1+4) @ 100°C	49	49
Scorch, 135°C, min. to 5 pt. rise	11.5	11.3
ts2, min.	4.4	4.4
t'90, min.	14.2	16.6
Physical Properties Cured t'90 @ 160°C		
Tensile Strength, MPa	13.6	14.8
300% Modulus, MPa	6.4	6.5
Elongation, %	580	570
Hardness, Shore A	60	60
Tan Delta, t'90+5 min. @ 160°C, 60°C/10 Hz/±5% Strain	0.094	0.083
Stain Migration (170 hr. exposure to UV light) Adjacent BSW; depth, mm	<3	<3
Dynamic Ozone, 100 pphm/ 40°C20% ext, hrs to crack	400+	400+

NEW TIRE WHITE SIDEWALL COMPOSITION Continued

Static Ozone, Bent Loop 100 pphm/40°C, hrs to crack	400+	400
Weatherometer - UV Crazing, hrs to crack	500+	500+
Outdoor DeMattia Flex, hrs to crack	500+	500+
Cured Strip Adhesion, kN/m, to NR/BR BSW		
@ Room Temperature	6.8(T)	5.4(T)
@ 100°C	2.1(T)	1.9(T)
Green Strip Tack @ RT, kN/m(x100)	26.3	42.0

*NR = SMR 5
(T) Stock tearing
(I) Interfacial separation

HEAT RESISTANT ENGINE MOUNT

Exxon

Natural Rubber	70.0
Exxpro MDX 90-10	30.0
N-550	55.0
Paraffininc Oil	15.0
Paraffin Wax	0.5
Petroleium Wax	0.5
6PPD	2.0
Zinc Oxide	2.0
CBS	2.0
Sulfur	0.5
Alkylphenol polysulfide resin	1.5
MDR, 1° Arc, 160°C, 30 minutes	
ML, dN.m	1.0
MH, dN.m	10.4
ts2, minutes	0.9
t'90, minutes	1.6
Physical Properties	
Hardness, Shore A	51
100% Modulus, MPa	2.5
300% Modulus, MPa	12.1
Tensile Strength, MPa	18.9
Elongation, %	434
Aged Physicals, 72 hours @ 125°C	
Hardness, Shore A	53
100% Modulus, MPa	2.9
300% Modulus, MPa	13.2
Tensile Strength, MPa	15.2
Elongation, %	331
Dynamic Properties, tested @ 15 Hz & 24°C	
Tan δ, Unaged	0.19
Tan δ, Aged 140 hours @ 150°C	0.21

AUTOMOTIVE AIR DUCT
DuPont Dow

Engage 8100	100.00
N550	100.00
Sunpar 2280	20.00
Vulcup 40KE	10.00
Zinc Oxide	5.00
TAC	1.50
Agerite Resin D	1.00
Total	**237.50**
Physical Properties (RT)	
Cure 10 minutes @ 175°C	
T-B, psi	1740
E-B, %	170
Hardness, Shore A	90
Low Temperature Brittleness	
Tested @ -55°C	Pass

ROLL COMPOUND

DuPont Dow

Engage 8180	100.00
N650	80.00
Sunpar 2280	30.00
Vulcup 40KE	10.00
Zinc Oxide	5.00
TAIC	2.00
PE617A	2.00
Naugard 445	2.00
Vanox ZMTI	2.00
Total	**233.00**
Physical Properties (RT)	
Press cured: tc(90) +5 min.@ 170°C	
T-B, psi	2250
MPa	15.52
E-B, %	264
Shore A,	78
Brittlepoint -70°C	Pass

FA ROLL COMPOUNDS
R.T. Vanderbilt

Masterbatch			
FA Polysulfide			100.0
ALTAX			0.35
VANAX DPG			0.15
Neophax A Regular			20.0
Second Pass			
Neoprene W			15.0
Zinc Oxide			10.0
Ethylene Thiourea			0.15
Stearic Acid			0.5
N-774 Carbon Black			Variable
Aromatic Process Oil			Variable
Variables			
N-774 Carbon Black, phr	30	40	50
Aromatic Process Oil, phr	40	30	20
Physical Properties, Cured 50 min. at 148°C(298°F)			
Hardness, Shore A	20	30	40
Tensile Strength, MPa (psi)	2.5(360)	2.8(410)	3.6(520)
Elongation, %	350	700	530
Volume Change after 1 week at 27°C(80°F)			
ASTM Fuel A, %	-13	-10	-16
ASTM Fuel D, %	21	20	22
Xylene, %	82	83	82
Toluene, %	120	112	112
Methyl Ethyl Ketone, %	33	30	30
Methyl Isobutyl Ketone, %	30	27	26
Ethyl Acetate, %	9	14	18
Acetone, %	-2	-4	0

TYPICAL ST COMPOUND
R.T. Vanderbilt

Polysulfide	100.0
N-774 Carbon Black	60.0
Stearic Acid	1.0
Calcium Hydroxide	1.0
Zinc Peroxide	5.0
Physical Properties, Cured 30 min. at 142°C(287°F)	
Hardness, Shore A	72
100% Modulus, MPa (psi)	3.1(440)
Tensile Strength, MPa (psi)	7.8(1130)
Elongation, %	265
Compression Set after 22 hours at 70°C(158°F)	
Set, %	25
Volume Change after 30 days at 27°C(80°F)	
ASTM Fuel A, %	1
ASTM Fuel D, %	14
Xylene, %	40
Toluene, %	70
Ethyl Acetate, %	35
Carbon Tetrachloride, %	46
Ethyl Alcohol, %	2
Acetone, %	37
Methyl Ethyl Ketone, %	35
Methyl Isobutyl Ketone, %	24

COMPOUNDS FOR ASTM D-2000, TYPE A, CLASS K
R.T. Vanderbilt

ASTM DESIGNATION	AK303	AK506	AK716	AK914
ST Polysulfide	100.0	100.0	100.0	95.0
LP-3 Liquid Polysulfide	---	---	---	5.0
Calcium Hydroxide	1.0	1.0	1.0	1.0
Zinc Peroxide	5.0	5.0	5.0	5.0
Stearic Acid	1.0	1.0	1.0	1.0
N-774 Carbon Black	25.0	30.0	---	---
N-110 Carbon Black	---	---	50.0	90.0
Aromatic Process Oil	20.0	5.0	---	---
Physical Properties, Cured 30 min. at 154>DEC (310°F)				
Hardness, Shore A	30	50	70	90
Tensile Strength,	2.4(350)	4.3	11.4	9.8
MPa(psi)		(620)	(1660)	(1420)
Elongation, %	490	430	486	230
Compression Set After 22 hours at 70°C(158°F)				
Set, %	38	33	31	48

LOW VOLTAGE CABLE INSULATION

DuPont Dow

Engage 8150	100.00
Whitetox Clay	125.00
Calcium Carbonate	125.00
Sunpar 2280	80.00
Vulcup 40KE	10.00
SR 350	3.00
Vinyl Silane	1.25
Agerite Resin D	1.50
Total	**445.75**
Physical Properties (RT)	
T-B, psi	1150
E-B, %	250
Dielectric Constant @ 1KHz	2.7

HIGH AND LOW DAMPING COMPOUNDS
R.T. Vanderbilt

Damping	Low	High
Norsorex N	100.0	100.0
Medium Visc. Naphthenic Oil	150.0	250.0
Dioctyl Adiphate (DOA)	50.0	50.0
THERMAX N-990 Carbon Black	100.0	---
N-774 Carbon Black	100.0	---
N-220 Carbon Black	---	200.0
AGERITE STALITE S	2.0	2.0
Zinc Oxide	5.0	5.0
Stearic Acid	1.0	1.0
DURAX	5.0	5.0
Sulfur	1.5	1.5
Physical Properties, Cured 10 min. at 160°C (320°F)		
Hardness, Shore A	42	50
100% Modulus, MPa (psi)	1.6(205)	1.5(190)
Tensile Strength, MPa (psi)	11.6(1690)	7.7(1120)
Elongation, %	330	270
Dynamic Properties, Tangent ?, 100 Hertz, 1% Strain		
@ 20°C(68°F)	0.15	0.35
@ 50°C(122°F)	0.13	0.29
@ 75°C(160°F)	0.10	0.24
@ 100°C(212°F)	0.08	0.20

CELLULAR SHOE SOLING

Uniroyal

Royalene 301T	30.00	
Elvax 260	70.00	
HiSil 233	30.00	
Zinc Oxide	2.00	
Zinc Stearate	2.00	
Celogen 754A	5.00	
Vulcup 40KE	6.00	
Sunpar 2280	25.00	
Total	**170.00**	
Rheometer, 163°C(325°F)		
ts2, min.	4:29	
tc50 min	6:30	
90% T	22.8	
	Press Cure	**Oven Age**
Time, min.	20	
Time, hours		5
Temp., °C	160	70
Temp.,°F	320	158
Density, lbs./ft^3	22	
Density, kg/m^3	352	
Specific Gravity	0.35	
Shrinkage, L&W, %	3 & 2.5	
Compression Set, %, ASTM D-1056F	12	

DUROMETER 65 EVA COMPOUND FOR CASTOR WHEELS
PPG

	Formula
EVA (12% VA; 2.5 MI)	100.0
Hi-Sil 233	70.0
Zinc Oxide	2.0
Zinc Stearate	2.0
Stearic Acid	1.0
Sartomer 350	6.0
Vulcup 40KE	6.0
(Percadox 14/40)	
	Mixing
Initial Temperatures: Banbury 110°C-120°C; Mill 70°C	
Dump Temperature 130°C - 140°C	
OD Rheometer 160°C;	
T2	2.5 minutes
T90	30 minutes
Minimum dN-m	44
Maximum	160
Durometer Shore D	66
M100, MPa (PSI)	17.2(2500)
Tensile	19.2(2800)
Elongation	160%
Flexural Modulus, MPa (PSI)	
At 23°C	355(51,200)
At 70°C	110(15,900)
At -30°C	790(116,700)

DUROMETERS 80 & 85 EVA COMPOUNDS FOR TRANSPARENCY
PPG

Durometer	**80**	**85**
EVA 150	70.0	100.0
EPDM 1040	30.0	--
Hi-Sil 255	30.0	--
Hi-Sil 233S	--	30.0
TAC	1.0	1.0
Zinc Stearate	--	0.5
DMBPH (101)	2.0	2.0
Cure Rate 160°C: T50 minutes	4.5	4.0
T90 minutes	22	20
Mooney Scorch 121°C, T5 min.	30+	30+
Viscosity ML100	41	25
Light Transmittance, (2 mm. Thickness)		
Transparency, %	83	74
Haze, %	21	--
Color	Water White	Water White
Durometer	80	86
M300, MPa (PSI)	7.0(1000)	7.9(1140)
Tensile	19)2800)	22(3150)
Elongation, %	510%	515%
Pendulum Rbound (Z), %		
At 23°C	59	61
At 100°C	59	56
Compression Set 3Days 100°C, %	--	28.9
PICO Abrasion Index		
At 23°C	--	138
At 100°C	80	62

DUROMETER 88 EVA COMPOUND FOR TEAR RESISTANCE
PPG

EVA 700				100.0
Silica or Black				50.0
Stearic Acid				2.0
PCB 50				3.0
TMQ				1.0
1.2 BR 150				4.0
BPDIB				3.0
Specific Gravity				1.25
Filler		Hi-Sil 190G		HAF N330
Cure Rate, MDR 160C, T50		4.3		15
T90		23		38
MDR Crosslinks, dN-m		46		43
Mooney Scorch 121C, T5		30+		30+
Mooney Viscosity, ML100		66		40
Cured 30/40’ @ 160C				
Durometer at 23C		87		87
at 100C		76		76
Stress/Strain	Original	Aged*	Original	Aged
Durometer	89	92	93	91
M100, MPa	5.1			13
Tensile	19	17	20	17
Elongation, %	315	85	150	110
MG Trouser Tear, kN/m		17		6.0
Pendulum Rebound (Z), %				
At 23C		20		19
At 100C		39		47

DUROMETER 92 EVA COMPOUND FOR FIRE RESISTANCE

PPG

Levapren 700		70.0
EPDM 346		30.0
Hi-Sil 210		50.0
Ricon 150		4.0
Stearic Acid		1.0
Rhenogran P50		3.0
BPDIB		2.8
Specific Gravity		1.22
Cure Rate MDR 160C, T50 minutes		4.6
T90 minutes		19
Mooney Scorch 121C, T5 minutes		30+
Mooney Viscosity ML100		54
Stress/Strain	Original	Aged 700 hrs. 150C
Durometer: 23C	92	95(Brittle)
100C	89	
M100, MPa	14	
Tensile	17	
Elongation, %	125	
MG Trouser Tear, kN/m		11(60 ppis)
PICO Abrasion Index @ 100C		55
Pendulum Rebound (Z) at 23C		32%
at 100C		51%

APPENDIX

CHEMICAL ABBREVIATIONS

ABS	Acrylonitrile butadiene styrene
ACM	Polyacrylate rubber
ADPA	Diphenylamine-acetone reaction product
APPD	N-alkyl N'-phenyl p-phenylenediamine
ASTM	American Society for Testing and Materials
BIIR	Bromobutyl rubber
BMDC	Bismuth dimethyldithiocarbamate
BR	Polybutadiene rubber
CBTS	N-cyclohexyl-2-benzothiazolesulfenamide
CdDEC	Cadmium diethyldithiocarbamate
CIIR	Chlorobutyl rubber
CM	Chlorinated polyethylene
CO	Epichlorohydrin (homopolymer) rubber
CuDMC	Copper dimethyldithiocarbamate
CPPD	N-cyclo-N'-phenyl-p-phenylenediamine
CR	Polychloroprene (neoprene)
CRF	Channel replacement furnace black
CSM	Chlorosulfonated polyethylene
CTP	N-(cyclohexylthio) phthalimide
CV	Continuous vulcanization
DBP	Dibutyl phthalate
DBPH	2,5 dimethyl 2,5 di(t-butylperoxy) hexane
DBTU	Dibutylthiourea
DCP	Dicumyl peroxide
DEG	Diethylene glycol
DETU	1,3-diethylthiourea
DIDP	Diisodecyl phthalate
DOA	Dioctyl adipate
DOP	Dioctyl phthalate
DOTG	Diorthotolylguanidine
DPG	Diphenylguanidine
DPPD	Diphenyl-p-phenylenediamine
DPTH	Dipentamethylenethiuram hexasulfide
DPTT	Dipentamethylenethiuram tetrasulfide
DPTU	Diphenylthiourea
DTDM	4,4'-dithiodimorphpline

EAA	Ethylene-acrylic acid copolymer
ECO	Epichlorohydrin rubber
EEA	Ethylene-ethylacrylate copolymer
ENR	Epoxidized natural rubber
EPC	Easy processing channel black
EPDM	Ethylenepropylenediene rubber
EPM	Ethylene propylene rubber (copolymer)
ETU	Ethylene thiourea
FKM	Fluoroelastomer
FVMQ	Fluorosilicone rubber
FZ	Polyphosphazene rubber
GR	Guayule rubber
HAF	High abrasion furnace black
HAV	Hot air vulcanization
HD	1,4-hexadiene monomer
HDPE	High density polyethylene
HER	Hydroxyethyl ethr of resorcinol
HMMM	Hexmethoxymethylmelamine
HMT (Hexa)	Hexamethylenetetramine
HNBR	Hydrogenated nitrile rubber
HNS	Hydroxylamine neutral sulfate
HPPD	N-1,1 dimethylbutyl-N’-phenyl-p-phenylenediamine
HSR	High styrene resin
HVBR	High vinyl polybutadiene rubber
IIR	Butyl rubber
IPPD	N-isopropyl-N’-phenyl-p-phenylenediamine
IR	Polyisoprene
IRB	Industry reference black
ISAF	Industry super abrasion furnace black
ISO	International Standards Organization
LCM	Liquid curing media
LLDPE	Linear low density polyethylene

MBOCA	Methylene bis(o-chloro anine)
MBM	m-phenylenebismaleimide
MBS	4-morpholinyl-2-benzothiazole disulfide
MBT	Mercaptobenzothiazole
MBTS	Benzothiazyl disulfide
MDA	Methylene dianiline
MDI	Methylene di-4-phenylisocyanate
MPFR	Methyol phenol formaldehyde resin
MQ	Silicone rubber
MT	Thermal carbon black
MTI	2-mercaptotoluimidazole
NBC	Nickel di-n-butyldithiocarbamate
NBR	Nitrile rubber
NR	Natural rubber
OBTS	N-oxydiethylenebenzothiazole-2-sulfenamide
ODPA	Di-octyl diphenylamine
OTOS	N-oxydiethylene-thiocarbamyl-N-oxydiethylene sulfenamide
PEG	Polyethylene glycol
PMQ	Methylphenyl silicone rubber
PPD	p-Phenylenediamine
PVC	Polyvinyl chloride
PVI	Prevulcanization inhibitor
PVMQ	Methylphenylvinyl silicone rubber
RSS	Ribbed smoked sheet (natural rubber)
RTV	Room temperature vulcanization
SAF	Super abrasion furnace black
SBR	Polystyrene butadiene rubber
SBS	Styrene-butadiene-styrene block copolymer
SPF	Super processing furnace black
SPH	Styrenated phenol
SRF	Semi-reinforcing furnace black
TAC	Triallylcyanurate
TAIC	Triallylisocyanurate
TBBS	N-t-butyl-2-benzothiazolesulfenamide

TBPB	t-butyl perbenzoate
TBSI	N-t-butyl-2-benzothiazole sulfenimide
TBTD	Tetrabutylthiuram disulfide
TBzTD	Tetrabenzylthiuram disulfide
TDEC	Tellurium diethyldithiocarbamate
TETD	Tetraethylthiuram disulfide
TiBTD	Tetra-isobutylthiuram disulfide
TMQ	Polymerized 1,2-dihydro-2,2,4-trimethylquinoline
TMTD	Tetramethylthiuram disulfide
TMTM	Tetramethylthiuram monosulfide
TPE	Thermoplastic elastomer
TPNR	Thermoplastic natural rubber
XNBR	Carboxylated nitrile rubber
ZBEC	Zinc dibenzyldithiocarbamate
ZBDC	Zinc dibutyldithiocarbamate
ZEDC	Zinc diethyldithiocarbamate
ZDiBC	Zinc di-iso-butyldithiocarbamate
ZMBT	Zinc mercaptobenzothiazole
ZMTI	Zinc mercaptotoluimidazole

TRADE-NAMED RAW MATERIALS

Trade Name	Chemical Description	Supplier
A172; A174; A189	Silane coupling agents	Osi
Adaphax	Sulfurless factice	Harwick
Adiprene	Millable polyurethane	Uniroyal
Admex	Polymeric plasticizers	Huls
Aflas	Tetrafluoroethylene/propylene	Dyneon
Agerite	Antioxidants	Vanderbilt
Aktisil	Silane treated fillers	Struktol
Altax	MBTS accelerator	Vanderbilt
Amax	MBS accelerator	Vanderbilt
Amberex	Factice	Harwick
Aminox	Diphenylamine-acetone	Uniroyal
Anox HB	Trimethyl dihydroquinoline	Great Lakes
Antilux	Wax blend	Rhein Chemie
Antozite 67	6PPD antiozonant	Vanderbilt
Arazate	Zinc diphenyl dithiocarbamate	Uniroyal
Armide	Oleamide	Akzo
Armoslip CP	Amide wax	Akzo
Atomite	Calcium carbonate	ECC Intl.
Benzoflex	Diethyleneglycol dibenzoate	Eastman
BIK	Treated Urea	Uniroyal
Bisoflex 111	Ether adipate	B P Chemical
BLE	Acetone-diphenyl amine	Uniroyal
Budene	Polybutadiene	Goodyear
Butazate	Butyldithiocarbamate	Uniroyal
Cabosil	Fumed silica	Cabot
Caloxol	Calcium oxide	Harwick
Captax	Mercaptobenzothiazole	Vanderbilt
Carbowax	Polyethylene glycol	OSi
Caytur	Isocyanate curatives for PU	DuPont
Celogen	Blowing agent	Uniroyal
Cereclor	Chlorinated paraffins	ICI
Chemigum	Nitrile elastomers	Goodyear
Cohedur RL	Resorcinol / HMMM	Bayer
Corax	Carbon blacks	Degussa
Cumar	Courmarone indene resins	Neville

Cyrez	HMMM Bonding agent	Cytec
DAP	Diallyl phthalate	C P Hall
Delac	Accelerators	Uniroyal
Desical P	Calcium oxide / oil	Harwick
DIAK	Curatives for fluoroelastomers	DuPont
DiCup 40	Dicumyl peroxide, 40%	Hercules
Dispergum N	Zinc fatty acids	Blachford
DSC 18	Mercaptopropyl triethoxysilane	Harwick
Durax	CBS accelerator	Vanderbilt
Durosil	Precipitated silica	Degussa
Dutral TER	EPDM elastomers	Enichem
Dyphos	Lead cure activators	N L Industries
Echo S	Thiadiazole	Hercules
Elastomag	Magnesium carbonate	Morton
Elvax	Ethylene vinvl acetate resins	DuPont
END 75	Ethylene thiourea	Rhein Chemie
Engage	Ethylene copolymers	DuPont Dow
Epon 828	Epoxy resin	Natrochem
Escorez	Tackifier resins	Exxon
Europrene N	Nitrile elastomers	Enichem
Flectol H	TMQ	Uniroyal
Flexamine	Antioxidant	Uniroyal
Flexol	Plasticizer	Union Carbide
Flexon	Petroleum oil	Exxon
Flexricin	Recinolate plasticizers	Harwick
Flexzone	Antiozonants	Uniroyal
Fluorel	Fluoro elastomers	3M
Glicogum	Polyethylene glycol	Great Lakes
Hakuenka CC	Precipitated calcium carbonate	H M Royal
Hallco 3425	Process aid	C P Hall
Hercoflex 900	Polyester plasticizer	Hercules
Hi-Sil	Precipitated silicas	PPG Industries
HVA 2	N,N’phenylene dimaleimide	DuPont Dow
Hycar 1312	Liquid NBR	Goodrich
Hydral 710	Aluminum trihydrate	Alcoa
Hydrin	Chlorohydrin elastomers	Zeon
HyTemp	Acrylic elastomers	Zeon

Intol	SBR elastomers	Enichem
Irganox	Antioxidants	Ciba-Geigy
Kadox	Zinc oxides	C P Hall
Keltan	EPDM rubber	DSM
Kenamide	Wax lubricant	Kenrich
Kenflex A1	Plasticizer	Kenrich
Ketjenblack	Conductive black	Akzo
Koresin	Butylphenol-acetylene	Struktol
Lithene AH	Polybutadiene, low M.W.	Revertex
Luperco	Peroxide curatives	Atochem
Maglite D	Magnesium oxide	Harwick
Marinco H	Magnesium hydroxide	Marine Magnesium
Mark	PVC stabilizers	Argus
Mesamoll	Phenol alkyl sulfonic esters	Bayer
Metalyn	Plasticizers	Hercules
Millathane	Millable polyurethanes	TSE
Mistron Vapor	Talc	Luzenac
Monex	TMTM accelerator	Uniroyal
Morfax	MDB accelerator	Vanderbilt
MP1500	Talc	Specialty Minerals
Multifex MM	Precipitated calcium carbonate	Specialty Minerals
Naugard	Antioxidants	Uniroyal
Naugawhite	Non-staining antioxidant	Uniroyal
Naugex	Accelerators	Uniroyal
Neophax	Factice	Harwick
Nipol	Nitrile elastomers	Zeon
Nipol DM	NBR / PVC elastomers	Zeon
Nordel	EPDM elastomers	DuPont Dow
Nucap	Mercaptosilane treated clay	Huber
Nulok	Amine silane treated clay	Huber
Nyad	Wollastonite	Nyco
Nysyn	Nitrile rubber	DSM
Octamine	DDPA antioxidant	Uniroyal
Octoate Z	Zinc Octoate	Vanderbilt
Opex	Dinitrosopentamethylene tetramine	Uniroyal
Paraplex	Polymeric plasticizers	C P Hall
PE 200	Pentaerthritol	Hercules

PE 617A	Polyethylene, low M.P.	Allied Signal
Percadox	Peroxides	Akzo
Perkacit	Accelerators	Flexys
Peroximon	Peroxides	Atochem
Plasthall	Plasticizers	CP Hall
Plioflex	SBR	Goodyear
Pliolite S6	High styrene SBR	Goodyear
Polygard	Nonyl phenyl phosphite	Uniroyal
Polymist	PTFE lubricant	Ausimont
Polyplastol	Fatty acids	Great Lakes
Profax	Polypropylene	Himont
Purecal	Calcium carbonate	Witco
Pyrax	Pyrophyllite	Vanderbilt
Regal 300	Carbon black	Cabot
Reofos	Iso-propylated phenylphosphate	Ciba-Geigy
Resin 741D	Disproportionated rosin	Hercules
Resinex	Aromatic hydrocarbon resin	Harwick
Rhenocure	Accelerators	Rhein Chemie
Rhenogran	Accelerator masterbatches	Rhein Chemie
Royalene	EPDM	Uniroyal
Santicizer	Ester plasticizers	Flexys
Santocure	Accelerator	Flexys
Santoflex	Antidegradants	Flexys
Santovar	Hydroquinone antioxidant	Flexys
Saret	Acrylic co-agents	Sartomer
Satintone W	Calcined clay	Engelhard
SI69	Triethoxysilylpropyl tetrasulfide	Degussa
Silene 732D	Precipitated silica	PPG Industries
Silteg	Aluminum Silicate	Degussa
Socal U	Calcium carbonate	LaPorte (UK)
Solflex	SSBR	Goodyear
SP6700	Phenol-formaldehyde resin	Schenectady
SR 1501	Resorcinol resin	Schenectady
SR 350, etc.	Acrylic co-agents	Sartomer
Stangard	Antioxidants	Harwick
Struktols	Process aids	Struktol
Sulfads	DPTT	Vanderbilt
Sundex	Aromatic oils	Sun Refining
Sunolite	Microcrystalling wax	Witco
Sunpar	Paraffinic oils	Sun Refining
Sunthene	Naphthenic oils	Sun Refining

Technoflon	Fluoro elastomers	Ausimont
Tellurac	Tellurium dithiocarbamate	Vanderbilt
Tenex	Wood rosin	Hercules
Tetrone A	DPHT	DuPont Dow
Thancure	Zinc chloride / MBTS	TSE
Thiate	Thiourea accelerators	Vanderbilt
Thiokol	Polysulfide elastomers	Morton
Tinuvin 622	Antioxidant	Ciba-Geigy
TiPure R960	Titanium dioxide	DuPont
TP90B	Alkoxyethyl formal	Morton Thiokol
TP95	Alkoxyethyl adipate	Morton Thiokol
Translink 555	Silane treated clay	Engelhard
Trigonox	Peroxides	Akzo
Tuads	Thiuram accelerators	Vanderbilt
Tuex	Thiuram accelerators	Uniroyal
Tyrin	Chlorinated polyethylenes	DuPont Dow
Unads	Thiuram accelerators	Vanderbilt
Vanax	Accelerators	Vanderbilt
Vanox	Antidegradants	Vanderbilt
Vanstay 9100	Antioxidant	Vanderbilt
VanWax H	Blended waxes	Vanderbilt
Varox	Peroxide curatives	Vanderbilt
Versamag	Magnesium hydroxide	Marine Magnesium
Vibrathane	Millable polyurethane	Uniroyal
Vistalon	EPDMs	Exxon
Viton B600	Fluoro elastomer	DuPont
Vocol	Phosphate accelerator	Flexys
VPA #3	Process aid	DuPont
Vulcan 5H	Carbon black	Cabot
Vulcup 40 KE	Dicumyl peroxide, 40% on clay	Hercules
Vulkalent A	NNDPA Retarder	Bayer
Vulkanol 85	Aromatic polyether	Bayer
Vulkanox	Accelerators	Bayer
Vulklor	Tetrachlorbenzoquinone	Uniroyal
Vultac 2	Alkylphenol disulfide	Atochem
Vultrol	N,Nitroso diphenyl amine	Uniroyal
WB212	Fatty acid blend	Struktol
Whitetex	Calcined clay	Engelhard
Wingstay	Antioxidants	Goodyear

Wingtack	Hydrocarbon resin	Goodyear
Zeolex	Sodium aluminum silicate	Huber
Zetax	Zinc mercaptobenzothiazole	Vanderbilt
Zetpol	HNBR	Zeon
Zimate	Dithiocarbamates	Vanderbilt
Zisnet FPT	Triazine triazole	Zeon

SUPPLIERS' DIRECTORY

3M Company
3M Center
Saint Paul, MN 55133
612-733-2087

Akzo Nobel Chemicals Inc.
3560 West Market St.
Akron, OH 444333
706-592-9121

Alcoa/ Industrial Chem. Div.
P.O. Box 300
Bauxite, AR 72011
800-860-3290

Allied Signal
Columbia Rd. & Park Ave.
Morristown, NJ 07960
201-455-5872

Amoco Chemicals
801 Warrenville Road
Lisle, IL 60532
800-621-4567

Argus Div., Witco Corp.
520 Madison Ave.
New York, NY 10022
212-605-3600

Ashland Chemical Co.
Indust. Chemical & Solvents Div.
P.O. Box 2219
Columbus, OH 43216
614-790-3333

Ausimont USA
10 Leonards Lane
Thorofare, NJ 08086
609-853-8119

Bayer
2603 West Market St.
Akron, OH 44313
330-836-0451

HL Blachford, Ltd.
2323 Royal Windsor Drive
Mississauga, ON Canada L5J1K5
905-823-3200

BP Chemical
4440 Warrensville Center Rd.
Warrensville Heights, OH 44128
216-586-6455

Cabot Corp.
Industrial Ruber Blacks
8000 Miller Court Easr
Norcross, GA 30071
800-472-4889

Cabot Corp., Tire Blacks
6600 Peachtree Dunwoody Rd.
Atlanta, GA 30326
770-399-8688

Ciba Specialty Chemicals
540 White Plains Rd.
Tarrytown, NY 10591
914-785-2000

CP Hall Co.
311 South Wacker Drive
Chicago, IL 60606
312-554-7400

Cytec Industries Inc.
5 Garret Mountain Plaza
West Paterson, NJ 07424
201-357-3100

Degussa Corp.
65 Challenger Rd.
Ridgefield Park, NJ 07600
201-641-6100

DSM Copolymer Inc.
P.O. Box 2591
Baton Rouge, LA 70821
800-824-0357

DuPont
10th & Market Street
Wilmington, DE 19898
800-441-7111

Dupont Dow Elastomers LLC
300 Bellevue Parkway
Wilmington, DE 19809
302-792-4346

Dyneon LLC
6744 33rd Street
North Oakdale, MN 55128
612-733-5353

Eastman Chemical Products
P.O. Box 431
Kingsport, TN 37662
615-229-2000

ECC International Inc.
5775 Peachtree Dunwoody Rd., NE
Atlanta, GA 30342
404-303-4411

Engelhard Corp.
101 Wood Ave.
Iselin, NJ 08830
908-205-5000

Enichem Elastomers America Inc.
2000 West Loop South
Houston, TX 77027
800-441-3646

Exxon Chemical Americas
13501 Katy Freeway
Houston, TX 77001
281-870-6000

Flexys America LP
260 Sprinside Drive
Akron, OH 44333
330-666-4111

Goodyear Chemical
1485 East Archwood Ave.
Akron, OH 44316
330-796-7480

Great Lakes Chemical Corp.
P.O. Box 2200
West Lafayette, IN 47906
317-497-6234

Harwick Chemical Corp.
60 South Seiberling St.
Akkron, OH 44305
330-798-9300

Hercules Inc.
Hercules Plaza
Wilmington, DE 19894
800-247-4372

Himont Inc.
2801 Centerville Rd.
Wilmington, DE 19850
302-996-6000

JM Huber Corp.
4940 Peachtree Industrial Blvd.
Norcross, GA 30071
770-441-1301

ICI
Wilmington, DE 19897
302-886-3811

Kenrich Petrochemicals Inc.
140 East 22nd St.
Bayonne, NJ 07002
201-823-9000

Luzenac America Inc.
8985 East Nichols
Englewood, CO 80112
800-325-0299

Marine Magnesium Co.
995 Beaver Grade Rd.
Coraopolis, PA 15108
412-264-0200

Morton International
100 North Riverside Plaza
Chicago, IL 60606
312-807-3328

Natrochem Inc.
Exley Ave.
Savannah, GA 31498
912-236-4464

Neville Chemical Co.
2800 Neville Rd.
Pittsburgh, PA 15225
412-331-4200

NL Industries
Wyckoffs Mill Rd.
Hightstown, NJ 08520
800-955-6661

Nyco Minerals Inc.
124 Mountain View Dr.
Willsboro, NY 12996
518-963-4262

Osi Specialties Group
39 Old Ridgebury Rd.
Danbury, CT 06810
800-295-2392

PPG Industries Inc.
One PPG Place
Pitttsburgh, PA 15272
412-434-2413

RT Vanderbilt Co. Inc.
30 Winfield St.
Norwalk, CT 06855

Revertex Americas
2700 Papin St.
St. Louis, MO 63103
314-771-7852

Rhein Chemie Corp.
1008 Whitehead Rd. Ext.
Trenton, NJ 08638
609-771-9100

Sartomer Co. Inc.
502 Thomas Jones Way
Exton, PA 19341
610-363-4100

Schenectady International Inc.
P.O. Box 1046
Schenectady, NY 12301
518-370-4200

Specialty Minerals Inc.
640 North 13th St.
Easton, PA 18042
610-250-3348

Struktol Co. of America
P.O. Box 1649
Stow, OH 44224
330-928-5188

Sun Refining & Marketing Co.
P.O. Box 7438
Philadelphia, PA 19101
800-832-4737

Technical Processing Co.
106 Railroad Ave.
Paterson, NJ 07509
201-278-4950

TSE Industries
5260 113th Avenue North
Clearwater, FL 34620
813-573-7676

Union Carbide Corp.
39 Old Ridgebury Rd.
Danbury, CT 06817
800-335-8550

Uniroyal Chemical Co. Inc.
World Headquarters
Middlebury, CT 06749
203-573-3630

Witco Corp.
One American Lane
Greenwich, CT 06831
203-552-3359

ZeonChemicals Inc.
P.O. Box 37620
Louisville, KY 40211
800-735-3388

USEFUL FACTORS AND CONSTANTS

Degrees Centigrade = 5/9 (Degrees F. -32.0)
Degrees Fahrenheit = 9/5 (Degrees C.) +32.0
Absolute Zero = -273.13°C. = -459.6°F

1 British Thermal Unit (B.T.U.) = 252 gram calories = 777.5 foot pounds
1 Gram Calorie = 4.185 joules = 3.968 x 10^3 B.T.U. = 3.087 foot pounds

Heat of fusion of ice = 79.24 calories per gram
Heat of vaporization of water = 535.9 calories per gram

Volume (V) of a gas at temp. (t°C.) and pressure (p) becomes:

$$V_o = V_o (273 + t_1)(p_o) / (273 + t_o)(p_1)$$

1 Gram-molecular volume of a gas at 760 mm press. and 0°C. = 22.4 liters

1 Atmosphere = 14.7 lbs. per sq. in. = 1.0333 kilograms per cm^2.

1 Kilogram per cm^2. = 0.9677 atmosphere = 14.22 lbs. per sq. in.
1 inch (pressure) of mercury = 13.6 inches of water

Coefficient of expansion of gases = 0.003665 per degree C.

1 Gram per cm^3. = 8.33 lbs. per gallon
Density of dry air at 0°C. and 760 mm. = 1.293 milligrams per cm^3.
Density of sea water = 1.025 grams per cm^3.
Mean density of the earth = 5.52 grams per cm^3.

Diameter of the earth = 12,754 kilometers = 7,926 miles

1 Degree of latitude at equator = 111.3 km = 69.2 miles

Acceleration of gravity (sea level, lat. 45°) = 980.60 cm per sec. per sec.
= 32.172 feet per sec. per sec.

1 Gram weight = 981 dynes (force) approximately

1 Watt = 0.00134 horse power = 44.3 foot pounds per min.
1 Kilowatt = 1000 watts = 1.341 horse power = 44300 foot pounds per min.

1 Horse Power = 33000 foot pounds per min. = 550 foot pounds per sec.
= 0.746 kilowatt

1 Radian = 180° / π = 57.29578° = 57° 17' 45"

1 Angstrom (Å) = 0.1 nanometer = 0.1 millimicron = 4 X 10^{-9} inch
1 Micron (μ) = one micrometer = 0.001 millimeter = 0.000 039 37 inch

Velocity of sound = 331.36 meters (1089 feet)/sec. in dry air at 0 °C (32 °F)
Velocity of light in a vacuum = 299,792.5 km/sec. = 186,282 miles/sec.

TENSILE STRENGTH CONVERSION TABLE

psi	*Mpa*	*kgf/cm²*	*psi*	*Mpa*	*kgf/cm²*
100	0.69	7.03	4100	28.27	288.3
200	1.38	14.06	4200	28.96	295.3
300	2.07	21.09	4300	29.65	302.3
400	2.76	28.12	4400	30.34	309.4
500	3.45	35.15	4500	31.03	316.4
600	4.14	42.18	4600	31.72	323.4
700	4.83	49.22	4700	32.41	330.4
800	5.52	56.25	4800	33.10	337.5
900	6.21	63.28	4900	33.78	344.5
1000	6.90	70.13	5000	34.48	351.5
1100	7.58	77.34	5100	35.16	358.6
1200	8.27	84.37	5200	35.85	365.6
1300	8.96	91.40	5300	36.54	372.6
1400	9.65	98.43	5400	37.23	379.7
1500	10.34	105.5	5500	37.92	386.7
1600	11.03	112.5	5600	38.61	393.7
1700	11.72	119.5	5700	39.30	400.7
1800	12.41	126.5	5800	39.99	407.8
1900	13.10	133.6	5900	40.68	414.8
2000	13.79	140.6	6000	41.37	421.8
2100	14.48	147.7	6100	42.06	428.9
2200	15.17	154.7	6200	42.75	435.9
2300	15.86	161.7	6300	43.44	442.9
2400	16.55	168.7	6400	44.13	450.0
2500	17.24	175.8	6500	44.82	457.0
2600	17.93	182.8	6600	45.51	464.0
2700	18.62	189.8	6700	46.19	471.1
2800	19.31	196.9	6800	46.88	478.1
2900	20.00	203.9	6900	47.57	485.1
3000	20.68	210.9	7000	48.26	492.1
3100	21.37	218.0	7100	48.95	499.2
3200	22.06	225.0	7200	49.64	506.2
3300	22.75	232.0	7300	50.33	513.2
3400	23.44	239.0	7400	51.02	520.3
3500	24.13	246.1	7500	51.71	527.3
3600	24.82	253.1	7600	52.40	534.3
3700	25.51	260.1	7700	53.09	541.4
3800	26.20	267.2	7800	53.78	548.4
3900	26.89	274.2	7900	54.47	555.4
4000	27.58	281.2	8000	55.16	562.5

TEMPERATURE CONVERSION TABLE

Locate temperature to be converted in unlabeled, middle column. Read °C equivalents to left, °F equivalents to right.

°C		°F	°C		°F
-56.7	-70	-94.0	104.4	220	428.0
-51.1	-60	-76.0	110.0	230	446.0
-45.6	-50	-58.0	115.6	240	464.0
-40.0	-40	-40.0	121.1	250	482.0
-34.4	-30	-22.0	126.7	260	500.0
-28.9	-20	- 4.0	132.2	270	518.0
-23.3	-10	14.0	137.8	280	536.0
-17.8	0	32.0	143.3	290	554.0
-12.2	10	50.0	148.9	300	572.0
- 6.7	20	68.0	154.4	310	590.0
-1.1	30	86.0	160.0	320	608.0
4.4	40	104.0	165.6	330	626.0
10.0	50	122.0	171.1	340	644.0
15.6	60	140.0	176.6	350	662.0
21.1	70	158.0	182.2	360	680.0
26.7	80	176.0	187.8	370	698.0
32.2	90	194.0	193.3	380	716.0
37.8	100	212.0	198.9	390	734.0
43.4	110	230.0	204.4	400	752.0
48.9	120	248.0	210.0	410	770.0
54.4	130	266.0	215.6	420	788.0
60.0	140	284.0	221.1	430	806.0
65.6	150	302.0	226.7	440	824.0
71.1	160	320.0	232.2	450	842.0
76.7	170	338.0	237.8	460	860.0
82.2	180	356.0	243.3	470	878.0
87.8	190	374.0	248.9	480	896.0
93.3	200	392.0	254.4	490	914.0
98.9	210	410.0	260.0	500	932.0

CONVERSION OF MASSES AND MEASURES

U.S. To Metric

Length

Inch	=	2.5400 centimeters
Foot	=	0.3048 meter
Yard	=	0.9144 meter
Mile	=	1.6093 kilometers

Area

Sq. in. (in^2)	=	6.4516 sq. cm (cm^2)
Sq. foot (ft^2)	=	0.0929 sq. meter (m^2)
Sq. yard (yd^2)	=	0.8361 sq. meter (m^2)
Sq. mile	=	2.5900 sq. kilometers (km^2)

Volume and Capacity

Cu. inch (in^3)	=	6.3871 cm^3
Cu. foot (ft^3)	=	28.3169 liters
Cu. yard (yd^3)	=	0.7646 cu. meter (m^3)
Pint (liquid)	=	0.4732 liter
Quart (dry)	=	0.9464 liter
Quart (liquid)	=	1.1012 liters
Gallon (liquid)	=	3.7854 liters

Mass

Grain	=	0.0648 gram
Ounce (avoir.)	=	28.3495 grams
Ounce (troy)	=	31.1035 grams
Pound (avoir.)	=	0.4536 kilograms
Pound (troy)	=	0.3732 kilograms
Short Ton (2000 lb.)	=	907.2000 kilograms
Long Ton (2240 lb.)	=	1016.0000 kilograms

Rubber Related

Adhesion (pli)	=	0.1751 kNm
Stress (psi)	=	0.006895 MPa
Torque (in•lb)	=	0.1130 N•m

Metric to U.S.

Length

Meter	=	39.3700 inches
Meter	=	3.2808 feet
Meter	=	1.0936 yards

Kilometer	=	0.6214 mile

Area

Sq. centimeter (cm^2)	=	0.1550 sq. inch (cm^2)
Sq. meter (m^2)	=	10.7639 feet (ft^2)
Sq. meter (m^2)	=	1.1960 sq. yards (yd^2)
Hectare	=	2.4710 acres
Sq. kilometer (km^2)	=	0.3861 sq. miles (U.S. Statute)

Volume and Capacity

Liter	=	1.0567 quarts (liquid)
Liter	=	0.2642 gallon (liquid)
Liter	=	61.0234 cu. inches
Cubic meter (m^3)	=	35.3147 cu. feet
Cubic meter (m^3)	=	1.3079 cu. yards
Cubic meter (m^3)	=	28.3776 bushels (dry)

Mass

Grain	=	15.4324 grains
Kilogram	=	35.2740 oz. (avoir.)
Kilogram	=	2.2046 lbs. (avoir.)
Metric ton (1000 kg)	=	2204.6200 lbs. (avoir.)

RubberRelated

Adhesion (kN/m)	=	5.7101 pli
Stress (MPa)	=	145.039 psi
Torque (N•m)	=	8.8507 in•lb

Unit of Force perUnit of Length

Metric		**Sl**		**U.S.**
1 kgf/cm	=	9.80665 N/cm	=	5.600 lbf/in
1 kgf/m	=	9.80665 N/m	=	0.672 lbf/ft
1 kgf/m	=	9.80665 N/m	=	2.016 lbf/yd
1 kgf/m	=	9.80665 N/m	=	0.0031 tonf/foot
1 kgf/m	=	9.80665 N/m	=	0.0010 tonf/yd
1 kgf/km	=	980665 N/km	=	3.547 lbf/mile

Unit of Force perUnit of Area

1 kgf/cm^2	=	98.0665 kPa	=	14.223 lbf/in^2
1 kgf/mm^2	=	9.80665 MPa	=	0.711 tonf/in^2
1 kgf/m^2	=	9.80665 Pa	=	0.2049 lbf/ft^2
1 Metric tonf/m^2	=	9.80665 kPa	=	0.1024 tonf/ft^2
1 Metric tonf/m^2	=	9.80665 kPa	=	0.919 tonf/yd^2

Units of Mass perUnit of Volume

1 kg/m^3	=	1 kg/m^3	=	1.686 lb/yd^3
1 kg/m^3	=	1 kg/m^3	=	0.0624 lb/ft^3
1 Metric ton/m^3	=	1 Mg/m^3	=	0.843 ton/yd^3
1 kg/liter	=	1 Mg/m^3	=	8.3454 lb/US gallon
bulk density	=	1Mg/m^3	=	62.427 lbs/ft^3

U.S.		**Metric**		**SI**
Units of Force perUnit of Length				
1 lbf/inch	=	0.1786 kgf/cm	=	175.1 N/m
1 lbf/foot	=	1.488 kgf/m	=	14.59 N/m
1 lbf/yard	=	0.496 kgf/m	=	4.86 N/m
1 tonf/foot	=	2976.0 kgf/m	=	29.18 MN/m
1 tonf/yard	=	992.0 kgf/m	=	9.73 MN/m
1 lbf/mile	=	0.2819 kgf/km	=	2.76 N/m

Units of Force perUnit of Area

1 lbf/in^2	=	0.0703 kgf/cm^2	=	6.895 kPa
1 tonf/in^2	=	1.406 kgf/cm^2	=	13.79 MPa
1 lbf/ft^2	=	4.883 kgf/m^2	=	47.88 Pa
1 tonf/ft^2	=	9.761 tonsf/m^2	=	5.72 kPa
1 tonf/yd^2	=	1.085 metric tonsf/m^2	=	0.64 kPa

Unit of Mass perUnit of Volume

1 lb/yd^3	=	0.5933 kg/m^3	=	0.5933 kg/m^3
1 lb/ft^3	=	16.018 kg/m^3	=	16.018 kg/m^3
1 ton/yd^3	=	1.186 metric ton/m^3	=	1.186 Mg/m^3
1 lb/US gallon	=	0.1198 kg/liter	=	0.1198 Mg/m^3