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Automotive Fuels Reference Book

Third Edition

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ISBN 978-0-7680-0638-4
SAE Order Number R-297
DOI 10.4271/R-297

Library of Congress Cataloging-in-Publication Data

Richards, Paul, 1956–

Automotive fuels reference book / by Paul Richards. — Third edition.
pages cm

Based on work originally published as Automotive fuels handbook / K. Owen.
Includes bibliographical references and index.

ISBN 978-0-7680-0638-4

1. Motor fuels—Handbooks, manuals, etc. I. Owen, K. (Keith). Automotive fuels handbook. II. Title.

TP343.R495 2014

629.25'38—dc23

2013041897

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To Bernard and the memory of Rita.

Contents

Preface to Third Edition	xxiii
Preface to Second Edition	xxv
Preface to First Edition	xxvii
 Chapter 1 Automotive Fuels and Their Specification	1
References	6
 Chapter 2 A History of Gasoline and Diesel Fuel Development	9
2.1 Gasoline	9
2.1.1 The Evolution of the Gasoline Engine	9
2.1.2 Gasoline Development	11
2.2 Diesel Fuel	19
2.2.1 The Evolution of the Diesel Engine	19
2.2.2 Diesel Fuel Development	24
References	28
Further Reading	29
 Chapter 3 Manufacture of Gasoline and Diesel Fuel from Crude Oil	31
3.1 Introduction	31
3.2 Crude Oil	31
3.3 Influence of Product Demand Pattern on Processing	32
3.4 Distillation	35
3.5 Cracking Processes	38
3.5.1 Thermal Cracking	39
3.5.2 Visbreaking	40
3.5.3 Coking	40
3.5.4 Catalytic Cracking	42
3.5.5 Hydrocracking	45
3.5.5.1 Catalytic Distillate Dewaxing	45
3.5.6 Steam Cracking	46

3.6	Catalytic Reforming	47
3.7	Alkylation, Isomerization, and Polymerization	49
3.7.1	Alkylation	49
3.7.2	Isomerization	50
3.7.3	Polymerization	51
3.8	Finishing Processes	51
3.8.1	Caustic Washing	51
3.8.2	Merox Treating	51
3.8.3	Hydrodesulfurization	52
3.8.3.1	Sources of Hydrogen	53
3.9	Oxygenated Gasoline Components	53
3.9.1	Alcohols	54
3.9.2	Ethers	55
3.10	Gasoline Blending	55
3.10.1	Blending Operations	57
3.10.2	Blending Calculations	58
3.10.3	Octane Blending	58
3.10.4	Reid Vapor Pressure (RVP) Blending	60
3.10.5	ASTM Distillation Blending	60
3.11	Diesel Fuel Blending	60
3.11.1	Diesel Blending Operations	61
3.11.2	Diesel Blend Calculations	62
	References	64
	Further Reading	67

Chapter 4 Manufacture of Gasoline and Diesel Fuel from Non-Crude Oil Fossil Sources 69

4.1	Introduction	69
4.2	Coal	69
4.2.1	Syn-Gas Production	71
4.2.2	F-T Synthesis	73
4.2.3	Product Upgrading	76
4.2.3.1	Hydrocracking	76
4.2.3.2	Oligomerization	77
4.2.3.3	Catalytic Reforming	77
4.2.3.4	Alcohol Dehydration	77
4.3	Gas to Liquids	77
4.4	Gaseous Fuels	80
4.4.1	Gaseous Fuel Supply	81
4.4.2	Gaseous Fuel Composition and Properties	82
4.4.2.1	Gaseous Fuel Components	82
4.4.2.2	Wobbe Index and Fuel Metering	84
4.4.2.3	Propensity to Knock: Octane and Methane Numbers	87

4.4.2.4 Effect of Gaseous Fuel Composition on Emissions	89
4.4.3 Gaseous Fuels Dispensing and Storage.	91
4.4.3.1 Compressed Natural Gas (CNG)	91
4.4.3.2 Recommended Practice for CNG: SAE J1616	93
4.4.3.3 LNG Dispensing and Storage	94
4.4.3.4 LPG Dispensing and Storage.	96
4.4.4 Gaseous-Fuel Engine Technology	96
4.4.4.1 Fuel Metering Systems.	96
4.4.4.2 Spark-Ignition Engines.	97
4.4.4.3 Dual-Fuel (Compression Ignition) Engines.	98
4.5 Oil Sands Fuel	99
4.5.1 Oil Sands Extraction and Processing	100
4.5.1.1 Surface Mining	100
4.5.1.2 Subterranean Recovery	103
4.5.1.3 In Situ Processing	104
4.6 Oil Shale Fuel	104
4.6.1 Oil Shale Mining and Processing	105
4.6.2 In Situ Retorting	105
References	106
Further Reading	111

Chapter 5 Manufacture of Gasoline and Diesel Fuel from Renewable Sources 113

5.1 Introduction.	113
5.2 Minimally Processed Vegetable Oil	116
5.3 Bio-Ethanol	117
5.3.1 Ethanol from Sugar Crops.	118
5.3.2 Ethanol from Grain Crops.	119
5.3.3 Lignocellulosic Ethanol	121
5.4 Biodiesel Fuel	122
5.5 Hydrotreated Vegetable Oil	127
References	130
Further Reading	136

Chapter 6 Storage, Distribution, and Handling of Gasoline and Diesel Fuel 137

6.1 Introduction.	137
6.2 Safety Considerations for Storage and Handling	138
6.2.1 Flash Point	138
6.2.2 Electrical Conductivity	138
6.3 Health and Environmental Effects of Gasoline	138
6.3.1 Health Aspects	139

6.3.1.1 Inhalation.....	139
6.3.1.2 Ingestion.....	139
6.3.1.3 Aspiration.....	139
6.3.1.4 Skin Contact.....	139
6.3.1.5 Eye Contact	140
6.3.2 Exposure Limits	140
6.3.3 Ecotoxicity	140
6.3.4 Disposal	141
6.4 Health and Environmental Effects of Diesel Fuel	141
6.4.1 Health Aspects	141
6.4.1.1 Inhalation.....	141
6.4.1.2 Ingestion.....	141
6.4.1.3 Aspiration.....	141
6.4.1.4 Skin Contact.....	142
6.4.1.5 Eye Contact	142
6.4.2 Exposure Limits	142
6.4.3 Ecotoxicity	142
6.4.4 Disposal	142
6.5 Influences on Product Quality during Distribution	142
6.5.1 Sea Transport.....	142
6.5.2 Pipeline.....	143
6.5.3 Road and Rail	144
6.6 Influences on Product Quality during Storage.....	145
6.6.1 Water Contamination in Tankage.....	146
6.6.2 Microbiological Contamination	146
6.6.3 Sludge in Tankage.....	146
6.6.4 Evaporative Losses.....	147
6.6.5 Oxidation	147
6.7 Considerations with Oxygenated Blends	148
6.7.1 Environmental Aspects of Fuels Containing MTBE	149
6.7.2 Water Sensitivity of Alcohol Blends.....	151
6.7.3 Safety and Fire Protection for Alcohol Blends	155
6.7.4 Oxidation Stability of Biodiesel	155
6.7.5 Cold Stability of Biodiesel.....	157
References	158
Further Reading	160

Chapter 7 Positive Ignition Engine Combustion Process 161

7.1 Normal Combustion.....	161
7.1.1 Mixture Requirements.....	161
7.1.2 The Combustion Process	162
7.2 Spark Knock	164
7.2.1 How Spark Knock Occurs.....	164
7.3 Measurement of Gasoline Antiknock Quality	167

7.3.1	Research and Motor Octane Number	167
7.3.2	Road Octane Number	170
7.3.3	Octane Index and Modern Engines	172
7.3.4	Influence of Chemical Structure on Octane Quality	175
7.4	Antiknock Additives	176
7.4.1	Lead Alkyls	176
7.4.2	MMT—Methylcyclopentadienyl Manganese Tricarbonyl	180
7.4.3	Other Metallic Antiknocks	181
7.4.4	Organic Antiknocks	182
7.4.5	Oxygenated Blending Components	183
7.5	Octane Blending	184
7.6	Octane Requirements of Vehicles and Engines	185
7.6.1	Vehicles with Knock Sensor Systems	187
7.6.2	Data Analysis	188
7.6.3	Octane Rating of Fuels Using Vehicles or Engines	189
7.6.4	Engine and Other Factors That Influence Octane Requirements	191
7.7	Octane Requirement Increase (ORI)	193
7.8	Other Abnormal Combustion Phenomena	194
7.8.1	Pre-Ignition	194
7.8.1.1	Fuel Quality Effects on Pre-Ignition	196
7.8.1.2	Deposits and Pre-Ignition	196
7.8.1.3	Inherent Fuel Resistance to Pre-Ignition	197
7.8.2	Misfire	199
7.8.3	Run-On	201
	References	202
	Further Reading	211

Chapter 8 Gasoline Engine Design and Influence of Fuel Characteristics 213

8.1	Introduction	213
8.2	The Gasoline Engine	214
8.2.1	Otto Cycle	214
8.2.2	The Atkinson Cycle	216
8.2.3	The Miller Cycle	218
8.3	Vehicle Fuel Systems	218
8.3.1	The Fuel Metering System	218
8.3.1.1	Carburetors	219
8.3.1.2	Throttle Body Fuel Injection	221
8.3.1.3	Port Fuel Injection	223
8.3.1.4	Direct Fuel Injection	225
8.3.2	The Fuel Tank and Pump	228
8.4	Ignition Systems	229
8.5	Combustion and Exhaust Emission Control Systems	230

8.5.1 Combustion Chamber Configuration	230
8.5.1.1 Combustion Chamber Shape.	230
8.5.1.2 Valve Layouts	231
8.5.2 The Effect of Air-to-Fuel Ratio	232
8.5.3 Exhaust Aftertreatment Systems	234
8.5.3.1 Oxidation Catalysts.	234
8.5.3.2 Three-Way Catalysts.	235
8.5.3.3 Lean NO _x Traps.	235
8.5.3.4 Particulate Filters	237
References	238
Further Reading	245

Chapter 9 Gasoline Volatility 247

9.1 Measurement of Gasoline Volatility.	250
9.1.1 Vapor Pressure	250
9.1.2 Reid Vapor Pressure	250
9.1.3 Dry Vapor Pressure and DVPE.	251
9.1.4 Distillation by ASTM D86	252
9.1.5 Vapor-Liquid Ratio.	254
9.1.6 Effect of Oxygenated Blending Components	255
9.2 Cold Starting	258
9.2.1 Different Fuel System Technologies.	258
9.2.1.1 Carbureted Engines	259
9.2.1.2 Port Fuel Injected Engines	259
9.2.1.3 Direct Injection Engines	259
9.2.2 Relevant Specifications	260
9.3 Cold Weather Driveability.	260
9.3.1 Cold Weather Driveability Test Procedures	261
9.3.1.1 U.S. Test Procedures	261
9.3.1.2 European Procedures	262
9.3.2 Relevant Fuel Parameters	263
9.3.2.1 U.S. Driveability Index.	264
9.3.2.2 European and Japanese Indices	264
9.4 Hot Weather Driveability	266
9.4.1 Hot Weather Driveability Testing.	266
9.4.2 Hot Weather Driveability Problems.	267
9.4.2.1 Fuel Weathering	267
9.4.2.2 Vapor Lock.	267
9.4.2.3 Carburetor Percolation.	267
9.4.2.4 Carburetor Foaming	267
9.4.3 Hot Weather Fuel Parameter Specification.	268
9.5 Evaporative Emissions from Vehicles	270
9.5.1 Measuring Evaporative Emissions.	271
9.5.2 Reducing Evaporative Emissions.	271

9.6 Influence of Fuel Volatility on Exhaust Emissions	273
9.7 Intake System Icing	273
9.7.1 Throttle Icing in Carbureted and Throttle Body Injected Engines	273
9.7.2 Throttle Icing in Multipoint Fuel Injected Engines	275
9.8 Oil Dilution and Combustion Chamber Deposits	275
9.9 Fuel Economy and Gasoline Volatility	276
References	277
Further Reading	285

Chapter 10 Influence of Gasoline Composition on Stability, Gum Formation, and Engine Deposits 287

10.1 The Influence of Gasoline Composition on Stability	287
10.1.1 Measurement of Stability	288
10.1.1.1 Measurement of Oxidation Stability by Induction Period Method	288
10.1.1.2 Automated Measurement of Induction Period	289
10.1.1.3 Measurement of Gum Content by Jet Evaporation	289
10.1.1.4 Measurement of Oxidation Stability by Potential Residue Method	289
10.1.1.5 Measurement of Long-Term Stability	290
10.2 Deposit Formation in Engines Due to Gasoline Oxidation	290
10.2.1 Deposit Formation in the Fuel Tank and Fuel Lines	291
10.2.2 Deposit Formation in Fuel Injectors and Carburetors	292
10.2.2.1 Chrysler 2.2	295
10.2.2.2 Other Vehicle-Based Injector Deposit Test	295
10.2.2.3 CRC Injector Deposit Bench Test	296
10.2.3 Deposit Formation in the Inlet Manifold, Ports, and on Valves	296
10.2.3.1 Opel Kadett Test	298
10.2.3.2 Mercedes-Benz M102E Test	299
10.2.3.3 BMW 318i Test	300
10.2.3.4 Mercedes-Benz M111 Test	300
10.2.3.5 Ford 2.3 Test	302
10.2.3.6 Other Engine Tests	302
10.2.3.7 Bench Simulator Rigs	302
10.2.3.8 Valve Stick Test	303
10.2.4 Combustion Chamber Deposits	304
10.2.4.1 Deposit Formation in Direct Injection Gasoline Engines	305
10.2.4.2 Combustion Chamber Deposit Interference	307
References	307

Chapter 11 Gasoline Additives317

- 11.1 Additives to Improve Oxidation Stability.....318
 - 11.1.1 Antioxidants318
 - 11.1.2 Metal Deactivators320
- 11.2 Additives Used in Gasoline Distribution321
 - 11.2.1 Dyes and Markers.....321
 - 11.2.2 Corrosion Inhibitors.....322
 - 11.2.3 Biocides322
 - 11.2.4 Anti-Static Additives323
 - 11.2.5 Drag Reducing Agents.....323
 - 11.2.6 Demulsifiers and Dehazers.....323
- 11.3 Additives Used to Protect Engines and Fuel Systems.....325
 - 11.3.1 Corrosion Inhibitors.....325
 - 11.3.2 Anti-icing Additives.....326
 - 11.3.3 Deposit Control Additives (DCAs)326
 - 11.3.3.1 Carburetor Cleanliness Additives326
 - 11.3.3.2 Port Fuel Injector Anti-Fouling Additives.....329
 - 11.3.3.3 Additives to Control Inlet Manifold, Inlet Valve, and Port Deposits330
 - 11.3.3.4 Additives for Direct Injection Injector Cleanliness.....331
 - 11.3.3.5 Combustion Chamber Deposit Control.....331
 - 11.3.4 Factory Fill Additives.....332
- 11.4 Additives That Influence Combustion332
 - 11.4.1 Antiknock Additives332
 - 11.4.2 Anti-ORI Additives332
 - 11.4.3 Anti-Pre-Ignition and Anti-Misfire Additives333
 - 11.4.4 Spark-Aider Additives.....334
 - 11.4.5 Additives for Improving Fuel Distribution between Cylinders334
 - 11.4.6 Anti-Valve-Seat Recession Additives.....335
- 11.5 Additives That Improve Lubricant Performance.....335
 - 11.5.1 Upper Cylinder Lubricants.....336
 - 11.5.2 Anti-Wear Additives336
 - 11.5.3 Friction Modifiers.....337
 - 11.5.4 Anti-Sludge Additives.....337
- 11.6 Multi-Functional Additive Packages.....338
- References339

Chapter 12 Other Gasoline Specification and Non-Specification Properties349

- 12.1 Density349
- 12.2 Heat of Combustion.....350

12.3	Composition	352
12.3.1	Hydrocarbon Composition	352
12.3.2	Elemental Composition	353
12.3.2.1	Lead.....	353
12.3.2.2	Manganese.....	354
12.3.2.3	Phosphorus	354
12.3.2.4	Sulfur.....	354
12.3.3	Oxygenates	356
12.3.4	Water.....	356
12.4	Flash Point.....	357
12.5	Surface Tension.....	357
12.6	Viscosity.....	358
12.7	Conductivity	358
12.8	Corrosivity.....	359
12.9	Freezing Point.....	359
12.10	Appearance	359
	References	360

Chapter 13 Influence of Gasoline Characteristics on Emissions 365

13.1	Development of Emissions Legislation and Fuel Quality Regulations	366
13.1.1	Development in the United States	366
13.1.2	Development in Europe.....	369
13.1.3	Development in Japan	370
13.1.4	Development in the Rest of the World	371
13.2	The Introduction of Reformulated Gasolines.....	372
13.2.1	The Adoption of RFG in the United States	372
13.2.2	RFG Specifications	374
13.2.3	European Experience of RFGs	375
13.2.4	The Fuel and Emissions Relationship Going Forward	375
13.3	The Influence of Gasoline Sulfur Content on Emissions	376
13.3.1	The Effect of Sulfur on Tail-Pipe Emissions	376
13.3.2	The Effect of Sulfur on Durability of Aftertreatment Systems	379
13.3.3	The Effect of Sulfur on Onboard Diagnostics.....	380
13.4	The Influence of Gasoline Hydrocarbon Composition on Emissions	384
13.4.1	Aromatics.....	385
13.4.1.1	Aromatics and Regulated Exhaust Emissions	385
13.4.1.2	Aromatics and Air Toxins	387
13.4.2	Olefins	387
13.5	The Influence of Gasoline Distillation Characteristics on Emissions	388
13.5.1	Front-End Volatility	389

13.5.2 Mid-Range Volatility	389
13.5.3 Back-End Volatility	390
References	391
Further Reading	399
Chapter 14 Racing Fuels	401
14.1 General Considerations	402
14.1.1 Safety	403
14.1.2 Volatility	403
14.1.3 Resistance to Detonation and Pre-Ignition	403
14.1.4 Flammability Limits	403
14.1.5 Flame Speed	403
14.1.6 Heat of Vaporization	404
14.1.7 Density	404
14.1.8 Heating Value	404
14.1.9 Stoichiometry	405
14.1.10 Specific Energy	405
14.2 Hydrocarbon Racing Fuels	406
14.2.1 Historical Perspective	407
14.2.2 Current Perspective	408
14.3 Alcohols as Racing Fuels	410
14.4 Antiknock Components	411
14.5 Nitro-Paraffins as Racing Fuels	413
14.6 Fuel Additives	414
14.6.1 Hydrazine	414
14.6.2 Antiknock Additives	414
14.6.3 Stabilizers	415
14.6.4 Deposit Control Additives	415
14.6.5 Dyes and Markers	415
14.6.6 Static Dissipaters	416
14.7 Nitrous Oxide as an Oxidant for Racing Fuels	416
References	417
Chapter 15 The Diesel Engine Combustion Process	421
15.1 The Diesel Combustion Process	422
15.1.1 Ignition Delay Period	424
15.1.2 Pre-Mixed Burning Period	426
15.1.3 Diffusion Burning Period	427
15.1.4 Tail-End Burning Period	427
15.2 Fuel Properties Influencing Combustion	428
15.2.1 Ignition Quality	429
15.2.1.1 Measurement of Cetane Number	429
15.2.1.2 Measurement of Derived Cetane Number	430
15.2.1.3 Measurement of Cetane Index	431

15.3 Emissions Characteristics of Diesel Combustion.....	432
15.3.1 Smoke and Particulates	433
15.3.2 Oxides of Nitrogen.....	435
References	437
Further Reading	443

Chapter 16 Diesel Engine Design and Influence of Fuel Characteristics445

16.1 Introduction.....	445
16.2 The Diesel Compression Ignition Engine	446
16.2.1 Direct Injection	446
16.2.2 Indirect Injection.....	447
16.2.3 Other Considerations.....	449
16.3 Diesel Vehicle Fuel Systems	449
16.3.1 Strainers, Filters, and Separators	451
16.3.2 Transfer or Lift Pumps.....	452
16.3.3 Injection Systems	452
16.3.3.1 Pump-Line-Nozzle Systems	453
16.3.3.2 Unit Injector Systems	459
16.3.3.3 High-Pressure Common Rail Systems.....	461
16.4 Exhaust Aftertreatment	463
16.4.1 Diesel Oxidation Catalysts	464
16.4.2 Diesel Particulate Filters	466
16.4.2.1 Deep Bed Filters	467
16.4.2.2 Wall Flow Filters	467
16.4.2.3 Partial Filtration	469
16.4.2.4 DPF Regeneration.....	469
16.4.3 NO _x Reduction Systems	471
16.4.3.1 Selective Catalytic Reduction	471
16.4.3.2 Hydrocarbon-Based NO _x Reduction	473
16.4.4 Integrated Systems.....	474
16.5 Influence of Fuel Properties on Engine Systems Performance	476
16.5.1 Influence of Fuel Density.....	476
16.5.2 Influence of Diesel Fuel Volatility	477
16.5.3 Influence of Diesel Fuel Viscosity.....	479
16.5.4 Influence of Diesel Fuel Composition	480
References	480
Further Reading	491

Chapter 17 Diesel Fuel Low-Temperature Characteristics ...493

17.1 Diesel Fuel Low-Temperature Properties	493
17.1.1 Cloud Point	494
17.1.2 Wax Appearance Point.....	495

17.1.3	Pour Point	495
17.1.4	Significance of Cloud Point and Pour Point	496
17.1.5	Cold Filter Plugging Point.	498
17.1.6	Low-Temperature Flow Test	500
17.1.7	Simulated Filter Plugging Point (SFPP)	501
17.1.8	Cold Soak Filtration Test	503
17.2	Additives to Improve Cold Weather Performance	504
17.2.1	Wax Crystal Modifiers (WCM)	504
17.2.2	Pour Point Depressants	505
17.2.3	Flow Improvers.	506
17.2.4	Cloud Point Depressants.	508
17.2.5	Wax Anti-Settling Additives (WASA)	508
17.2.6	Mechanism of Wax Crystal Modification	510
17.2.7	Factors Influencing Choice of Wax Modifier Additive	512
17.2.8	The Incorporation of Biodiesel	516
17.3	Measurement of Diesel Fuel Low-Temperature Performance	519
17.3.1	Selection of Field Test Site	520
17.3.2	Procedure for Low-Temperature Testing	520
17.3.2.1	Cold Startability	520
17.3.2.2	Cold Operability	521
17.3.3	Fuel Storage.	521
17.3.4	Vehicle Instrumentation.	521
17.3.5	Preparation of Test Vehicles	522
17.3.6	Operational Procedure.	522
17.3.7	Climate Chamber Testing	523
17.3.8	Interpretation of Results	525
17.3.9	Low-Temperature Test Experience.	526
17.3.10	Reducing Sensitivity to Waxing Problems by Vehicle Design	526
17.3.11	Experience with Modified Fuel Systems.	528
	References	529

Chapter 18 Influence of Diesel Fuel Composition on Stability and Engine Deposits 535

18.1	The Influence of Diesel Fuel Composition on Stability.	536
18.1.1	Petroleum Fuel Composition Effects	537
18.1.2	Biodiesel Composition Effects	538
18.1.3	Measurement of Stability.	540
18.1.3.1	Measurement of Storage Stability	540
18.1.3.2	Measurement of Thermal Stability	541
18.1.3.3	Measurement of Oxidation Stability	542
18.2	Engine Deposits	543

18.2.1	Deposit Formation in the Fuel Tank, Lines, and Filters	545
18.2.2	Internal Diesel Injector Deposits (IDID)	546
18.2.2.1	Carbonaceous Deposits	546
18.2.2.2	Metal Salts	547
18.2.2.3	Lacquer Deposits.	548
18.2.2.4	IDID Test Methods	549
18.2.3	External Injectors Deposits	550
18.2.3.1	Peugeot XUD-9 Test Method	551
18.2.3.2	Cummins L10 Test Method	553
18.2.3.3	Peugeot XUD-9A Test Method	556
18.2.3.4	Peugeot DW10 Test Method	557
	References	560

Chapter 19 Diesel Fuel Additives 569

19.1	Additives to Improve Fuel Stability.	570
19.2	Additives Used to Aid Distribution and Handling of Diesel Fuel.	572
19.2.1	Additives to Aid Cold Flow Performance	572
19.2.2	Corrosion Inhibitors	573
19.2.3	Static Dissipater Additives	574
19.2.4	Dehazers and Demulsifiers	574
19.2.5	Biocides	575
19.2.6	Anti-Foamants.	576
19.2.7	Odor Masks and Odorants	576
19.2.8	Dyes and Markers.	576
19.2.9	Drag Reducers.	577
19.2.10	Anti-Icers	577
19.3	Additives Used to Protect Engines and Fuel Systems.	577
19.3.1	Deposit Control Additives.	577
19.3.2	Lubricity Additives.	580
19.4	Additives That Influence Combustion	582
19.4.1	Ignition Improvers	582
19.4.2	Combustion Improvers	585
19.4.3	FBCs for DPF Regeneration.	587
19.5	Multi-Functional Additive Packages	588
	References	589

Chapter 20 Other Diesel Specification and Non-Specification Properties 599

20.1	Diesel Fuel Stability	599
20.2	Corrosivity	600
20.3	Ignition Quality.	600
20.4	Lubricity.	601

20.4.1	Evaluation of Different Test Methods	.603
20.4.2	Ball on Three Seats Method (BOTS)	.604
20.4.3	Ball-On-Cylinder Lubricity Evaluator (BOCLE)	.605
20.4.4	High-Frequency Reciprocating Rig (HFRR)	.605
20.5	Water and Sediment Content	.606
20.6	Ash Content	.608
20.7	Carbon Residue	.608
20.8	Density	.609
20.9	Heating Value	.610
20.10	Flash Point	.611
20.11	Electrical Conductivity	.611
20.12	Appearance and Color	.612
	References	.612

Chapter 21 Influence of Diesel Fuel Characteristics on Emissions 617

21.1	Development of Emissions Legislation and Fuel Quality Regulations	.618
21.1.1	Development in the United States	.618
21.1.1.1	California Risk Reduction Program for Diesel PM	.621
21.1.2	Development in Europe	.622
21.1.2.1	Measurement of PN	.624
21.1.3	Development in Japan	.625
21.1.4	Development in the Rest of the World	.626
21.2	Diesel Fuel Cetane Number and Emissions	.626
21.2.1	Effect of CN under Fully Warm Operating Conditions	.628
21.2.1.1	Pre-1990 Studies	.628
21.2.1.2	Studies During the 1990s	.629
21.2.1.3	Studies in the 21st Century	.630
21.2.2	Effect of CN under Cold Start Condition	.632
21.2.3	Natural and Improved CN	.634
21.3	The Influence of Diesel Fuel Physical Characteristics on Emissions	.636
21.3.1	Diesel Fuel Density Effects	.636
21.3.1.1	Density Emissions Correlations	.638
21.3.1.2	The Influence of Fuel Density on Emission Control Systems	.640
21.3.2	The Influence of Viscosity	.641
21.3.3	Diesel Fuel Distillation Characteristics and Emissions	.641
21.4	The Influence of Chemical Composition of Diesel Fuel on Emissions	.642
21.4.1	Diesel Fuel Sulfur Effects on Emissions	.642

21.4.1.1 The Effects of Fuel Sulfur on Tailpipe Emissions	643
21.4.1.2 Effect of Sulfur on Diesel Aftertreatment Systems	643
21.4.2 The Influence of Aromatic Content on Emissions	645
21.4.2.1 Effect of Total Aromatics Content on Emissions	646
21.4.2.2 Effect of Fuel Di- and Tri-Aromatic Content on Emissions	647
21.4.3 The Influence of Oxygenate Content on Emissions	648
21.4.3.1 The Influence of Biodiesel on Exhaust Aftertreatment Systems	649
References	651
Further Reading	662

Chapter 22 The Kinetically Controlled Compression Ignition Engine and Combustion Process 663

22.1 Brief History of Kinetically Controlled Combustion	665
22.2 The Low-Temperature Combustion Process	667
22.3 Low-Temperature Combustion Engines	669
22.3.1 The CAI Gasoline Engine	669
22.3.2 The PCCI Diesel Engine	671
22.3.3 The RCCI Engine	673
22.4 Fuel Effects on Kinetically Controlled Compression Ignition	674
22.4.1 Fuel Effects on CAI Engine Performance	675
22.4.2 Fuel Effects on PCCI Engine Performance	676
22.4.3 Fuel Effects on RCCI Engine Performance	678
References	679
Further Reading	686

Chapter 23 Future Trends and Alternative Fuels 687

23.1 Fossil Fuel Price and Security of Supply	689
23.1.1 Crude Oil	690
23.1.2 Other Oil Sources	691
23.1.3 Coal	691
23.1.4 Natural Gas	692
23.2 Renewable Fuel Price and Availability	692
23.2.1 Bio-Ethanol Feedstocks	692
23.2.2 Biodiesel Feedstocks	692
23.3 Environmental Considerations and Legislation	693
23.4 Vehicle Technology Advances	694
23.4.1 Gasoline Engine Development	695
23.4.2 Diesel Engine Development	696

23.4.3 Hybrid Electric Vehicles.	698
23.4.4 Hydrogen-Powered Vehicles.	699
23.4.4.1 Hydrogen as a Fuel for Spark Ignition Engines	700
23.4.4.2 Hydrogen Fuel Cell Vehicles.	703
23.5 Alternative Fuels.	705
23.5.1 Dimethyl Ether as a Fuel for Diesel Engines	705
23.5.2 Other Alternative Fuels	706
References	707
Further Reading	716
Appendix 1 Introduction to Fuel Chemistry	717
1.1 Hydrocarbons	717
1.2 The Alkanes or Paraffins, C_nH_{2n+2}	718
1.3 The Cycloparaffins or Naphthenes, C_nH_{2n}	719
1.4 The Alkenes or Olefins, C_nH_{2n}	719
1.5 The Aromatic Hydrocarbons, C_nH_{2n-6}	720
1.6 Combustion of Hydrocarbons	722
1.7 Monohydric Alcohols, $C_nH_{2n+1}OH$	723
1.8 Alkyl Ethers, $(C_nH_{2n+1})_2O$	724
1.9 Combustion of Oxygenates.	725
Appendix 2 Physical Properties of Hydrocarbons	727
Appendix 3 Worldwide Fuel Charter Recommendations	733
Test methods for gasoline properties.	735
Gasoline specifications—recommended limits	737
Test methods for diesel fuel properties	739
Diesel fuel specifications—recommended limits.	741
Appendix 4 Composition of Biodiesel from Different Feedstocks	743
Appendix 5 Material Safety Data Sheets	751
Appendix 6 Abbreviations and Acronyms	779
Appendix 7 Glossary of Terms.	791
Index.	819
About the Author.	839

Preface to Third Edition

In the first and second editions of this book, the authors tried to include those aspects of automotive fuels that are most likely to be needed by automobile engineers, oil technologists, commercial and academic research establishments, fuel additive manufacturers, and personnel from governmental agencies dealing with the control and specification of these fuels. In writing this third edition I have tried to keep faithful to the goals and standards of the original authors, Keith Owen and Trevor Coley. I have also tried to follow the layout of their original concept.

Gasoline and diesel fuel continue to be the most commonly used automotive fuels, although alternative fuels such as liquefied and compressed natural gas (LNG and CNG) and liquefied petroleum gas (LPG) are covered. In the previous editions the vast majority of gasoline and diesel fuels were produced from crude oil with only a small proportion being made by the gas-to-liquids process, either from gasified coal or directly from natural gas, or from other fossil sources. The proportion of fuel being derived from these other fossil sources has now increased and as a result it has also been given its own chapter. Fuels such as ethanol and plant oil derivatives that were once thought of as alternative are now widely used blending components to increase the renewable component of gasolines and diesel fuels. A new chapter has thus been included discussing the manufacture of gasoline and diesel fuel from renewable sources. The use of renewable fuels will inevitably grow, with increasing research aimed at developing more energy and land efficient alternatives.

Another area of change since the second edition has been the general growth in popularity of the diesel passenger car (the United States is probably an exception to that), and increasingly stringent regulation of diesel exhaust emissions. While the stability, deposit forming tendency, and influence of fuel characteristics on emissions were covered in the previous edition, I believe their growing importance now warrants separate chapters to mirror those for gasoline that were previously included. In respect of emissions legislation and fuel effects, the previous edition of this book included appendices that were taken from CONCAWE report 4/94. This report has since been updated every few years and has grown in stature. Due to the increased volume of that work and its ready availability via the Internet, it is no longer thought necessary to include the full sections of that report in this book. The latest version is listed as further reading at the end of the appropriate chapters. The website can be checked for later updates at www.CONCAWE.org

Automotive fuels are of interest worldwide, and for this reason this book has been written to cover, as far as possible, the many situations that exist throughout the globe. While leaded gasoline is sold to the populace in very few countries, it is still formulated for motorsport and aviation use. Thus it is still of interest to the fuel technologist to retain the information on lead antiknock additives. Similarly, although carbureted cars are now part of the legacy fleet, they are still an important part of the fleet in some countries, and so how fuel characteristics affect these vehicles is thus also of interest. Similarly high-pressure common-rail fuel injection equipment is becoming de rigueur for diesel engines, but the older style pump-line-nozzle systems are still to be found. I have therefore retained much of what Keith and Trevor wrote regarding engine technology while adding what is new, although I have tried to restrict discussion to passenger car technology and performance.

I would now like to acknowledge with grateful thanks the assistance of many friends and colleagues throughout the various industries who have supplied material, reviewed my work, and provided advice. They are listed alphabetically by affiliation: Jerry Burton of Advanced Fuel Solutions (Chester) Ltd., Richard Jones at BP International Limited, Les Wolf at BP Products North America, Inc., Roger Hutcheson of Cameron Associates, Ken Rose at CONCAWE, Jan Tucker at the Coordinating Research Council, Inc., Diane Lance at Coryton Advanced Fuels Ltd., Nobuyasu Ohshio at Comso Oil Co., Ltd., Markus Paule at Daimler AG, Philip J. Dingle at Delphi Diesel Systems, Bruce Beaver of Duquesne University, Nigel Elliott at ExxonMobil Research & Engineering, Steven Szwabowski at Ford Motor Company, John Maddox at Infineum UK Ltd., Trevor Russell and Jim Barker at Innospec Ltd., Naoki Shimazaki of Isuzu Advanced Engineering Center, Ltd., Wendy Clark at the National Renewable Energy Laboratory (NREL), Scott Curran of Oak Ridge National Laboratory, Ray Hooley of the Ray Hooley Collection, John Dec at Sandia National Laboratories, Paul Schaberg at Sasol Technology (Pty) Ltd., Nicki Welding and Roger Cracknell at Shell International Limited, Richard S. Jackson at Tesco Petrol Filling Station, Jan Czerwinski at the University of Applied Sciences Biel-Bienne, Yoshiyuki Kidoguchi at The University of Tokushima, Phil Easdown of www.vintagegarage.co.uk, Nigel Mathewson (no affiliation), plus Colette Wright, Martha Swiss, and Heather Slater at SAE International. Finally, I'd like to express my deep gratitude to my wife, Julie, for her support and patience during the many months of this project.

Paul Richards
March 2013

Preface to Second Edition

The pace at which changes are taking place in the domain of automotive fuels has necessitated a number of revisions to bring the Handbook up to date.

Although the first edition was published as recently as October 1990, there has been a significant change of emphasis with the wider introduction of reformulated fuels for both spark-ignition and compression-ignition engines, and in the types of additive for primary and secondary treatment of diesel fuels.

The other major area of change—and growth—is in environmental legislation against noxious and undesirable exhaust emissions from road vehicles. We are grateful to CONCAWE, the oil companies' European organization for environment, health and safety, for permission to incorporate their latest update on the situation in the appendices.

A new chapter has been contributed by Mr. C. S. Weaver to give more attention to the growing interest in the use of liquefied and compressed natural gas (LNG and CNG) and liquefied petroleum gas (LPG) as more environmentally friendly automotive fuels.

In view of concerns about automotive fuels and emissions, a section giving the health and environmental effects of gasolines and diesel fuels has been added.

The opportunity has been taken to increase the usefulness of the Handbook (and to resolve some uncertainties about units commonly used in the petroleum industry) by including Tables of Conversion and Heating Values. Inevitably, it has also been necessary to extend the list of abbreviations and acronyms which proliferate, often without explanation, in many technical publications.

Restructuring in Europe is also bringing in new names and abbreviations. At the end of 1993, the Single Europe Act came into effect, replacing the European Community (EC) with the European Union (EU). In May 1994, approval was given by the European Parliament to applications by four member countries of the European Free Trade Association (EFTA) to join the EU. The application by Norway was withdrawn after a referendum rejected joining but the other three countries, Austria, Finland, and Sweden, formally became members on January 1, 1995. Further enlargement and designation changes may occur if Eastern European countries are admitted but efforts will be made to minimize confusion in a situation which is still evolving.

The authors are appreciative of the advice and guidance provided by Don Goodsell, Ryozi Kato, former Esso/Exxon colleagues and other contributors during the preparation of this revision of the Handbook.

Keith Owen and Trevor Coley
January 1995

Preface to First Edition

In this book we have tried to include those aspects of automotive fuels that are most likely to be needed by automobile engineers, oil technologists, commercial and academic research establishments, fuel additive manufacturers, and personnel from governmental agencies dealing with the control and specification of these fuels. Because such a wide range of people of varying disciplines are likely to be interested, we have included, as Appendix I, a brief outline of fuel chemistry for those readers who are unfamiliar with the chemical symbols and equations used, even though these have been kept to a minimum. A glossary of terms has also been included, although most terms will have been explained at some point in the text.

Automotive fuels are of interest worldwide and for this reason this book has been written to cover, as far as possible, the global situation rather than the position in any single country. Thus, although leaded fuels are now of limited interest in many countries, their use will continue in some parts of the world well into the next century and so we thought it necessary to include a full discussion on such fuels.

By far the most common of the currently used automotive fuels are gasoline and diesel, so it is inevitable that most of the book is taken up by these fuels. Alternative fuels such as LPG or ethanol are, however, very important in some countries and there are indications that other alternative fuels could become important in the future. In particular, methanol looks as if it eventually could become the fuel of the future and is discussed in some detail, along with ethanol, in Chapter 19. A chapter on racing fuels has also been added because this is a subject of some interest on which comparatively little has been written.

Without government intervention, the use of alternative fuels in diesel engines appears to be a fairly remote possibility. Environmental pressures are leading to ever-tighter legislation against diesel exhaust emissions, but the major variations in levels of particulates and gases are associated with the engine rather than the fuel. However, although the costs of modifications to engines, vehicles and distribution systems are substantial, methanol is being evaluated as a “clean” alternative diesel fuel by several bus fleet operators in the U.S., Japan and Canada.

Because vehicle emission regulations are indirectly related to automotive fuels, we have incorporated as an Appendix a summary of current

emissions legislation as compiled by CONCAWE (the oil companies' European Organization for Environmental and Health Protection) and included with their kind permission. Legislation is changing at a rapid rate and so we have generally restricted our comments in the text to the general principles governing the formation of these emissions and particularly how they are influenced by fuel quality.

Chapter 15, which covers diesel fuel low-temperature characteristics, includes a section on the measurement of low-temperature performance. Direct comparison of results obtained by different organizations is often difficult because of variations in test techniques. This measurement procedure, which includes testing in the field as well as in climatic chambers, provides guidance on vehicle instrumentation, cooling phases, driving patterns, etc. We hope that it will be accepted as the basis for an industry standard so that future test data will be more readily comparable with each other.

Regarding units, we have tried to stick to the SI system although there are some instances where alternative units are used. In these cases the units are widely accepted and commonly used.

Finally, we would like to acknowledge with grateful thanks the assistance of many friends and colleagues who read various parts of the text and who improved the book with their helpful comments. In addition, we would like to thank Lucas Diesel Systems for their assistance with the chapters concerning diesel fuels. We are extremely grateful to the Esso/Exxon Chemicals Research Centre at Abingdon in the U.K., who made available to us the use of their Information Centre, and we thank particularly Miss Andrea Strafford and her colleagues who carried out for us many computer-based literature searches and who provided copies of papers, and without whose help we would never have been able to complete this task.