

Diesel Engine and Fuel System Repair

Fifth Edition



***John F. Dagel
Robert N. Brady***

Contents

1 INTRODUCTION, 1

Technician Professionalism and Image, 1
Career Advancement, 3
ASE Certification, 3
ASE Diesel Engines Task List, 4
Service Technicians Society, 8

2 DIESEL ENGINE OPERATING FUNDAMENTALS, 10

Diesel Engine Classifications, 10
Four-Stroke-Cycle Operation, 10
Two-Stroke-Cycle Operation, 15
Comparison of Two- and Four-Stroke-Cycle Designs, 18
Engine Firing Orders, 21
Summary, 22
Self-Test Questions, 22

3 UNDERSTANDING HORSEPOWER AND RELATED TERMS, 26

Understanding Power Terms, 26
Heating Value Equivalents, 47
ISO Standards, 47
Summary, 48
Self-Test Questions, 48

4 COMBUSTION SYSTEMS, 50

ASE Certification, 50
The Combustion Process, 50

Types of Combustion Chambers, 50
Combustion Dynamics, 53
Fuel Injection Timing, 56
Retarded versus Advanced Timing, 58
Exhaust Emissions Limits, 58
Summary, 59
Self-Test Questions, 62

5 ENGINE DISASSEMBLY CONSIDERATIONS, 63

Engine Cleaning Procedures, 75
Safe Work Habits When Cleaning, 75
Quality Assurance, 77
Summary, 77
Self-Test Questions, 78

6 THE CYLINDER BLOCK AND LINERS, 79

ASE Test Specifications, 79
ASE Cylinder Block Specialist, 80
Cylinder Block Structure, 82
Diesel Engine Cylinder Blocks, 84
Disassembly, Inspection, and Cleaning of the Cylinder Block, 88
Block Flowchart Inspection, 89
Systematic Overview of Engine Block Checks, 93
Final Inspection, Testing, Reconditioning, and Assembly, 96
Cylinder Hones, 105
Summary, 116
Self-Test Questions, 116

7 CRANKSHAFTS, MAIN BEARINGS, VIBRATION DAMPERS/PULLEYS, FLYWHEELS, AND FLYWHEEL HOUSINGS, 119

ASE T2 Test Specifications, 119
 ASE M2 and M3 Test Specifications, 119
 Crankshaft Structure and Function, 120
 Crankshaft Cleaning and Inspection, 123
 Repair or Replacement of Crankshaft Main Bearings, 126
 Main Bearing Defects and Remedies, 126
 Spun Main Bearings, 134
 Main Bearing Specifications and Crankshaft Tolerances, 135
 Main Bearing and Crankshaft Installation, 136
 Crankshaft Seals, 140
 Vibration Dampers, 142
 Flywheels, 148
 Purposes of Flywheels, 148
 Flywheel Designs and SAE Size, 149
 Flywheel Timing Marks, 149
 Removing and Inspecting the Flywheel, 149
 Ring Gear Replacement, 152
 Pilot Bearing Replacement, 154
 Flywheel Installation, 154
 Flywheel Runout, 155
 Flywheel Housing, 156
 Summary, 157
 Self-Test Questions, 158

8 PISTONS, PISTON RINGS, AND CONNECTING ROD ASSEMBLY, 161

ASE Diesel Engines Test, 161
 ASE Engine Machinist Tests, 161
 ASE Assembly Specialist Tests, 162
 Piston Structure and Function, 162
 Two-Piece Piston Designs, 164
 Piston Crown Shapes, 168
 Piston Operating Temperatures, 169
 Piston Removal from the Block, 173
 Pistons and Piston Rings, 174
 Piston Scuffing Identification, 177
 Piston Rings Inspection Details, 180
 Inspecting the Connecting Rods, 182
 Checking Rod Bore Ovality, 183
 Piston Pin Inspection, 185
 Final Assembly of Pistons, Piston Rings, and Connecting Rods, 185
 Summary, 193
 Self-Test Questions, 193

9 THE CYLINDER HEAD AND COMPONENTS, 196

ASE Certification, 196
 Cylinder Head Structure and Function, 198
 Service Recommendations, 201
 Summary, 227
 Self-Test Questions, 227

10 CAMSHAFT, CAM FOLLOWERS, PUSHRODS, ROCKER ARMS, AND TIMING GEAR TRAIN, 229

ASE Certification, 230
 System Structure and Function, 231
 Camshaft Cleaning and Inspection, 237
 Cam Follower Inspection, 240
 Pushrod Inspection, 240
 Rocker Arm Inspection, 242
 Valve Adjustment, 243
 Inspection, Replacement, and Assembly of the Timing Gear Train, 245
 Summary, 249
 Self-Test Questions, 249

11 LUBRICATION SYSTEMS AND LUBE OIL, 250

ASE Certification, 250
 Lubrication System Function, 250
 System Components, 252
 Engine Lube Oil, 258
 Waste Oil Disposal, 262
 Lube Oil Dilution, 262
 Oil Analysis, 263
 Inspection and Overhaul of Components, 263
 System Testing, 267
 Testing and Troubleshooting the Lube System, 267
 Engine Prelubrication, 268
 Starter Motor Prelube Systems, 270
 Summary, 270
 Self-Test Questions, 270

12 COOLING SYSTEMS, 272

ASE Certification, 272
 Cooling System Function, 273
 Engine Heat Loads, 274
 Coolant Flow Determination, 277
 Radiators, 278
 Radiator Shutters, 280
 Fan Clutches, 280

- Thermostats, 283
- Coolant, 287
- Cylinder Liner Pitting, 288
- Fill-For-Life Coolant, 289
- Antifreeze, 289
- Testing the Coolant, 291
- Scale Buildup, 292
- Coolant Filters, 292
- Flushing the System, 292
- Pressure Caps, 293
- Pressure Checking the Cooling System, 295
- Expansion Tanks and Heat Exchangers, 296
- Raw Water Pumps, 299
- Keel Cooling Systems, 300
- Summary, 301
- Self-Test Questions, 302

13 AIR INLET AND EXHAUST SYSTEMS, 304

- ASE Certification, 304
- The Air Supply, 305
- Intake and Exhaust System Flow, 306
- Air Cleaners, 307
- Air Ducting Inspection, 316
- Aftercoolers, 317
- Turbochargers, 321
- Exhaust Mufflers and Particulate Traps, 334
- Gear-Driven Blowers, 335
- Marine Engine Applications, 338
- Troubleshooting Using Manometers, 339
- Exhaust Brake Devices, 343
- Exhaust Brakes, 344
- Williams Exhaust Brake, 344
- Engine Compression Brakes, 346
- Electric Retarder, 358
- Use of Starting Fluids, 359
- Summary, 361
- Self-Test Questions, 361

14 DIESEL FUEL, FILTERS, AND FUEL/WATER SEPARATORS, 365

- ASE Certification, 365
- Diesel Fuel Oil Grades, 365
- Specific Gravity of a Fuel, 366
- Heat Value of a Fuel, 366
- Fuel Filtration, 368
- Fuel Filters, 369
- Fuel Filter/Water Separators, 371
- Fuel Heaters, 376
- Summary, 377
- Self-Test Questions, 377

15 TYPES OF FUEL SYSTEMS, 379

- ASE or TQ Certification, 379
- Basic Fuel Injection System, 379
- Distributor Pump System, 382
- Stanadyne DS Pump, 385
- Delphi Automotive Systems, 388
- Delphi Distributor Pumps Overview, 389
- DP200, 392
- DPC, 392
- DPCN, 393
- EPIC, 394
- DCR (Delphi Diesel Common Rail System), 396
- EUI (Electronic Unit Injector), 397
- Summary, 398
- Self-Test Questions, 398

16 MECHANICAL AND ELECTRONIC GOVERNOR OPERATION, 399

- Governor Function, 400
- Why a Governor Is Required, 400
- Mechanical Governor Operation, 401
- Governor Terms, 405
- Types of Governors, 407
- Zero-Droop Governors, 407
- Adjustable-Droop Governors, 408
- Electronic Governors, 414
- Summary, 416
- Self-Test Questions, 416

17 INJECTION NOZZLES, 419

- ASE Certification, 419
- Injectors, 421
- Nozzles, 422
- Nozzle Structure and Function, 423
- Nozzle Flow, 425
- Nozzle Components, 425
- Bosch Nozzles, 426
- Injector Nozzle Sac Volume, 427
- Nozzle Problems, 427
- Nozzle Removal, 427
- Testing Nozzles for Performance, 429
- Nozzle Disassembly and Cleaning, 432
- Injection Nozzle Reassembly, 436
- Nozzle Installation, 438
- Summary, 438
- Self-Test Questions, 438

18 THEORY OF ELECTRONIC FUEL SYSTEMS, 439

- ASE L2 Test, 439
- Electronic Fuel System Background, 442
- Advantages of Electronic Engines, 443
- Fuel System Structure and Function, 444
- ECM Serial Data/Sensor Communications, 450
- Engine Protection System, 460
- Electronic Unit Injectors, 464
- Electronic Control Modules, 469
- Troubleshooting Options, 474
- Diagnostic Tooling, 478
- Summary, 485
- Self-Test Questions, 485

19 ROBERT BOSCH CORPORATION FUEL SYSTEMS, 488

- ASE Certification, 488
- Company Background, 489
- Overview, 490
- Product Overview, 491
- Pump Features, 493
- Inline Pump Fuel System, 497
- Fuel Supply Pump Operation, 498
- Injection Pump Operation, 499
- Fuel Metering (Measurement), 499
- Helix Shapes and Delivery Valves, 502
- Inline Pump-to-Engine Timing, 504
- Overview: Static Spill Timing, 506
- Air-in-the-Fuel System, 509
- Cummins C Model Timing Check, 510
- Timing PF Jerk Pumps, 514
- Automatic Timing Advance Device, 515
- Basic Fuel System Troubleshooting, 516
- Robert Bosch Governors, 520
- Aneroid/Boost Compensator Control, 529
- Altitude Pressure Compensator, 530
- Robert Bosch Electronic Diesel Control, 531
- Distributor Pumps, 532
- Robert Bosch Model VE Injection Pump, 535
- Checking Injection Pump Static Timing, 547
- Robert Bosch VE Injection Pump
 - Troubleshooting, 548
- Electronic Distributor Pump, 550
- Testing/Setting Injection Pumps, 552
- Bosch Common-Rail Fuel Systems, 555
- Summary, 559
- Self-Test Questions, 559

20 MACK ELECTRONIC FUEL SYSTEMS, 564

- VMAC System Troubleshooting, 565
- Summary, 567
- Self-Test Questions, 568

21 DETROIT DIESEL CORPORATION FUEL SYSTEMS, 569

- ASE Certification, 569
- Engine Labels, 569
- Basic Fuel System Functions, 570
- Mechanical Fuel System Components, 570
- Fuel Pump, 570
- Minimum Fuel-Line Sizes versus Restriction, 574
- Priming the Fuel System, 575
- Filter Replacement, 575
- Engine Runs Out of Fuel, 576
- Fuel Injectors—MUI, 577
- Fuel System Troubleshooting, 579
- DDC Two-Stroke-Cycle Engine Tune-Up:
 - Non-DDEC Engines, 583
- Tune-Up Sequence, 583
- Detroit Diesel Series 50/60 Four-Stroke-Cycle
 - Engines—Tune-Up, 593
- Model 790 Jake Brakes—Flatbrake, 594
- Detroit Diesel Electronic Systems, 596
- Diagnostic Tooling, 609
- Optimized Idle, 614
- Electronic Unit Pump System, 615
- Summary, 616
- Self-Test Questions, 616

22 CUMMINS FUEL SYSTEMS, 620

- ASE Certification, 620
- Company Background, 620
- PT Fuel System, 621
- PT Fuel Pumps, 625
- AFC Pumps, 629
- Manual Fuel Shutoff, 630
- PT Pump Checks and Adjustments, 630
- Engine-to-Injector Timing, 631
- Step Timing Control System, 637
- Cummins Celect System, 643
- Diagnostic Fault Codes, 654
- ISB Engine Electronic Fuel System, 663
- Bosch VP44 Distributor Pump, 665
- Cummins—ISC Engines, 668