Diesel Engines and Fuel Systems
Acknowledgements vi
Preface vii
1 Some important terms 1
2 Comparing petrol and diesel engines 5
3 The mechanical cycles 12
4 The engine indicator and theoretical heat cycles 18
5 The combustion process 24
6 Combustion chambers 27
7 Cylinder head and valves 38
8 Cylinder block 66
9 Crankshaft assembly 87
10 Pistons, rings and connecting rods 111
11 Timing gears, camshaft and rocker gear assembly 136
12 Bearings 156
13 Seals and gaskets 165
14 Cold starting aids 179
15 Diesel engine fuels 184
16 Engine lubrication 190
17 Cooling systems 209
18 Air intake and exhaust systems 226
19 Turbochargers and blowers 241
20 Engine brakes 266
21 Engine faultfinding and testing 275
22 Fuel supply systems 296
23 Fuel supply pumps 301
24 Fuel filters 305
25 Injectors and injector nozzles 314
26 Single and multi element in-line injection systems 339
27 Distributor-type injection systems 387
28 Caterpillar diesel fuel systems 445
29 Cummins diesel fuel systems 482
30 Detroit Diesel fuel systems 514
31 Governors 536
32 Electronic system diagnostics 562
33 Engine emission controls 569
34 Alternative fuels 576
Index 579
Index

Advance device injection pump 396, 412, 421, 436, 446
Air cleaner 228
air intake problems 236
dry element type 229
oil bath 235
pre-cleaner 226
service 233
service indicator 233
vacuator valve 231
Air-fuel ratio control (AFC) 439, 488, 572
Air intake - diagnosing problems 236
Alternative fuels 576
alcohol 577
diesel fuel 576
gas ignition system 578
gaseous fuels 578
liquid fuels 576

vegetable oils 578
Atomiser, see injector
Automotive distillate, see Fuel, diesel

Bearings engine 87
see also bearings general
big end bearing measurement 126
camshaft 146
construction 89
crush 90
design 87
failure analysis 102-104
inspection 99
main bearing measurement 105
physical features (crankshaft) 89
removal 99
spread 90
Bearings general 156
ball and roller 159
bushes 157
inspection 158
removal-fitting 158
classes 156
inspection 162
needle roller 160
purpose 156
plain type 157
preloading 163
refitting 163
removal 161
split bearings 157
thrust bearing 160
types of load applied 156
Biological contamination (of fuel), see Fuel, biological contamination
Blower 258
bypass type 265
operation 260
service 261
Bosch enclosed camshaft injection pump, see Injection pump, enclosed camshaft, Robert Bosch
Bosch VE type injection pump 429
advance unit 436
air-fuel ratio control (AFC) 439
anti-reverse operation 439
construction 429
fuel system layout 429
governor 433
operation 429
starting aids 438
timing pump to engine 439
Bosch VE type injection pump electronic control 44
closed loop circuitry 443
ingine governing 443
Diesel engines and fuel systems

exhaust gas recirculation 444
injector needle motion sensor 443
fuel metering 442
operational data acquisition 442
self-diagnosis 444
system layout 441
Brake mean effective pressure 1
Brake power 2, 282, 295
Bump clearance 84
adjustment 86
Bypass oil filter, see Oil filter, bypass

Cam followers 138
inspection 147
mushroom type 139
roller type 139
Cam lobes 138
measuring lobe height 144
Camshaft 137
bearings 146
installation 149
removal and inspection 145
service 144
Caterpillar injection pump 445
auto timing advance 446
compact pump 445
dynamic timing 453
electronic engine controls 466
fuel rack adjustment 453
injectors 455
injector testing 457
new scroll pump 448
priming 455
Caterpillar electronic engine controls 466
controls 471
electronic control module (ECM) 478
electronic control system 474
fuel system layout 479
progressive gear shifting 473
system diagnostics 477
three-cylinder cutout 473
throttle position sensor 479
Caterpillar electronic unit injection 470
unit injector operation 480
Caterpillar unit injection 459
fuel pressure 466
fuel setting 462
governor 459
governor adjustment 466
injector synchronisation 460
injector timing 464
operation 458
valve clearances 466
Centrifugal oil filter, see Oil filter, centrifugal

Cetane number 185
Charge air pressure 249
Clearance volume 5
Clerk cycle 12
Cloud point (of fuel) 186
Cold start device 179, 438
Combustion chambers 27-37
compression swirl 33
direct injection 28
energy cell (air cell) 35
precombustion 32
removal 51
Combustion 24
stages 25
Compression ignition 6
Compression pressure 9, 134
Compression ratio 5
Compression stroke 12, 142
Compression swirl combustion chamber, see combustion chamber, compression swirl
Compression temperature 10
Compression test 134, 275
Connecting rod 119
alignment 125
measurement 125
service 120, 124
big end bearing measurement 126
Continuous power 284
Cooling system 209
aftercooler 221
air cooling 222
coolant 212, 220
fan 215
hydraulic oil cooler 219
marine engine cooling 217
oil cooler 218
overcooling 222
overheating 219
radiator 211
radiator cap 212
thermostat 213, 220
transmission oil cooler 218
water pump 215, 221, 223
Counterbore, see cylinder block
Crack detection 62
electro-magnetic 63
dye penetrant 62
pressure testing 64
Crankcase dilution 27
Crankshaft 87
alignment check 96
assembly 108
bearings 87
clearance 101, 105
crush 90
spread 90
cleaning 108
drip float 110
grinding 98
inspection 96, 97
measurement 97
oil seals 91
installation 105
polishing 98
removal 96
replacement 99
service 95
torsional forces 94
vibration damper 94, 95
Cross scavenging 15
Crosshead, see valve bridge
Cummins electronic engine control 496
Celect self-diagnosis 510
Celect system layout 497
Celect system operation 507
Celect injector operation 508
Celect injector setting 512
original equipment manufacturer harness 505
sensor harness 502
system components 501
system features 497-500
variable performance ratings 500
Cummins fuel system 482
air fuel ratio 488
button 486
fuel pressure control 485-487
fuel system layout 483
governor 485-486
injector adjustments, dial indicator method 494
top stop torque method 495
torque method 493
operation 484, 490
PT fuel pump 484
PT injectors 489-491
servicing 493
step timing control 491
throttle shaft 486, 488
Cylinder block 66
air cooled 66
cleaning 70
counterbores 75
exploded view 67
flatness check 75
service 70
main bearing tunnel alignment 80
Cylinder bore, see cylinder liner
Cylinder head 38
combustion chamber removal 51
cleaning 46
crack detection 59, 62
exploded view 39
flatness check 47
head height 57
inspection 46
installation 61
repair 46
removal 45
service 47
tightening 61
Cylinder liner 66
deglazing 78, 79
dry type 68
inspection 73
installation 82
measurement 71
protrusion 70, 76
removal 73
ridge removal 78
service 73
wet type 69
Damper, see vibration damper
Decompressor, see engine decompressor
Delay period 25, 318
Delivery valve 342, 344
Detroit Diesel engine 16
operation 17
Detroit Diesel electronic engine controls 523
diagnostic data reader 531
electronic control module 524
electronic unit injector operation 525
sensors 527
on-board diagnosis 529
Detroit Diesel fuel system 514
adjusting the control racks 522
fuel system layout 514
functions 516
governor 522
injector 515
injector construction 515
operation 514-517
service 521-523
timing unit injectors 521
Diagnostic fault/blink codes 477, 501-502, 529, 564
Diesel engine testing 282
Diesel knock 26
Direct injection 28
Directional ports 30
Distributor type injection systems, see Bosch VE, DPA, DPS, Roosa Master
DPA fuel injection pump 387
automatic advance 396
bleeding system 416
construction 387, 388
disassembly 403
governor
  hydraulic 400
  mechanical 398
hydraulic head 392
inspection of components 405
maximum fuel adjustment 394
metering valve 392
operation 387, 395
reassembly 406
regulating valve 389
rotor and plunger assembly 393
service 402
testing and adjusting 410
timing to engine 415
transfer pump 391
DPS fuel injection pump 418
  auto advance 421
  fuel system layout 417
  fuel-pump testing 424
  latch valve 420
  mechanical governor 422
  operation 418
  pump to engine timing 424
  scroll plates 418
Dribble test, see Injector service, dry seat test
Dynamometer 285
  hydraulic 286
  chassis 285
  electric 286
  PTO 286
Electronic engine control 336
  Caterpillar 471
  Cummins 496
  Detroit Diesel 523
  in-line pump 380
  VE pump 441
Electronic engine control system diagnostics 562
Electronic unit injector
  Caterpillar 470
  Cummins 508
  Detroit Diesel 525
Energy cell combustion chamber, see Combustion chamber, energy cell
Engine balancing 92
Engine brake 266
  engine brake controls 268, 269
    Cummins engine 270
    Dynatard 271
    Jacobs 266
  operation 266-269
  Engine decompressor 154
    adjustment 154
  Engine fault diagnosis 133
    blow-by test 133
    compression test 134
  Engine emission controls 569
    diesel exhaust gases 569
    emission controls 569
    electronic controls 572
    noise control 574
  Engine faultfinding 275
  Engine indicator, see indicator, engine
  Engine lubrication 190
    contamination of oil 200
    engine service classification 199
    lubricating oils 196
    oil analysis 201
    oil cooler 192
    oil cooler testing 207
    oil filter 193
    oil pump service 203
    pre-lubricating prior to start up 154
    system layout 191
  Engine run-in 155, 292
  Engine testing 257, 282, 288
    dynamometers 285
    running-in an engine 292
    standards 284
    testing an engine 288
    variations in power output 284
Exhaust brake 273
  operation 273
  Exhaust system 237
  Exhaust mufflers 238
  Exhaust smoke 279
  Exhaust stroke 12, 143
Fault finding chart, engine 276-278
Flashpoint 185
Flywheel 92
  runout 107
  wear evaluation 106
Force 1
Four-stroke cycle 12-14
Fuel feed pump 301
  diaphragm type 303
  plunger type 301
Fuel filter 305
  Bosch type 307
  CAV type 310
  filter material 306
  injector filter 313
  parallel filter 309
  series filter 310
Alternative fuels

Fuel heater 297
Fuel injection pressure 314
Fuel injection pump, in-line, see Injection pump, in-line type
Fuel pipe 298
Fuel sediment bowl 311, 312
Fuel specifications 184
Fuel storage 187
Fuel supply pump, see Fuel feed pump
Fuel supply system 296
  gravity feed 296
  pressure feed 298
Fuel temperature, effects of 285
Fuel, diesel 184
  automotive distillate 184
  biological contamination 188
  calorific value 185
  Cetane number 185
  cloud point 186
  flash point 185
  ignition quality 184
  industrial 184
  pour point 186
  sediment content 187
  self-ignition temperature 185
  specific gravity 186
  sulphur content 186
  viscosity 186
  winter grade 184
Fuel, winter grade 184
Full flow oil filter, see Oil filter, full flow

Gaskets 173
  cylinder head 176
  installation 174-175
  liquid sealing compound 174
Glow plug 179
  operation 179
  system layout 180
Governor 536
  combined 555
  hydra-mechanical 556
  mechanical 540
    simple constant speed 540
    simple idling and maximum speed 541
    simple variable speed 541
  pneumatic 550
  terminology 537
  Woodward SG 557
  operation 558

Heat cycle 20
  constant-pressure cycle 20
  constant-volume cycle 21
  mixed 22

Hydra-mechanical governor 556
Hunting 538

Ignition quality (of fuel), see Fuel, ignition quality
Indicated mean effective pressure 1
Indicated power 1
Indicated thermal efficiency 3
Indicator diagram 18
Indicator, engine 18
Indirect injection 28, 32-37
Inertia 1
Inertia force (engine) 92
Injection pump, in-line 339
  construction
    electric control device 345
    enclosed camshaft 345
    operation 343-345
    pump to engine timing 379
    servicing 366
    testing and setting 373
Injection pump, in-line electronic control 380
  control unit 381
  monitoring functions 383
  special functions 383
  system layout 382
Injection pump, single-element, flange-mounted 340
  balancing deliveries 365
  calibration 364
  disassembly 353
  inspection of components 355
  installation 363
  operation 343
  reassembly 358
  service 351
Injection pump timing 379
Injector 314
  back-leakage test 324
  dry seat or dribble test 323
  microjector 320
  nozzle types 317-321
  operation 316
  pressure test 322
  Roosa Master pencil 321
  reconditioning, nozzle 329
  service 321
  spray pattern test 324
  testing 322
  typical construction 314
Injector sleeve 45
Injector tester 323
Injector testing 322
Injector nozzle 317
  delay pintle 318
  hole type 317
  long stem 318
multi-hole 318
Pintaux 319
pintle 318
Injector nozzle protrusion 58
Injector sleeve 45
Inlet stroke 12, 142
Intercooler, air-to-air 247
Intercooler, air-to-water 247
testing core 256
Intercooling 245
Intermittent power 284
ISO testing fluid 372
Isochronous governor 539

Joule 1

Kadenacy system 16
Kilowatt 282

Lanova energy cell 35
Liner, see Cylinder liner
Liner protrusion, see Cylinder liner
Locking devices 176
lock type compounds 177
Loop scavenging 16

Manifold heater, see Thermostart
Manometer (u-tube) 289
Mechanical efficiency 2
Microjector 320
Mixed cycle 22

Net kWbp 282
Newton 1

Oil additives 197
anti-foam 198
anti-scuff 198
corrosion inhibitors 197
detergent/dispersant 197
oxidation inhibitors 197
pour point depressant 198
viscosity index improvers 198
Oil bath air cleaner, see Air cleaner oil bath
Oil classification 198
Oil cooler 192
Oil dilution 200, 202
Oil filter 193
bypass 194
centrifugal 195
full flow 193
Oil, function 196
Oil pressure relief valve 191, 206
Open combustion chamber 28
Otto cycle 12

Pascal 1
Piston 111
analysing problems 131
assembly to connecting rod 127
cam ground 113
cooling 113
dimension 123
height 131
inspection 121
installation 129
pin 114
offset 114
service 120
trunk type 111
two piece type 112
Piston cavity 28
Piston cooling 113, 248
Piston oil sprays 83
Piston ring 115, 128
barrel faced 117
breakage 133
compression 116
installation 129
internal step 118
keystone 117
oil control 118
rectangular 116
ring groove 122
service 120
tapered face 118
Pneumatic governor 550
Pop test, see Injector service, pressure testing
Pour point (of fuel), see Fuel, pour point
Pour point depressants, see Oil, pour point depressant
Power 1, 282 also see indicated power and brake power
Power stroke 12, 143
Power, variation of 284
Pre-cleaner 226, 227
Precombustion chamber 32
Pressure, barometric 285
Pushrods (camshaft) 148

Quick start system 59

Rated speed 537
Roosa Master Injection pump 425-429
adjustments 428
charging cycle 426
discharge cycle 426
fuel system layout 427
operation 425
pump to engine timing 428
service 428
Running-in an engine 292
Scavenging 13-17
Seals 165
  causes of seal leakage 171
  exclusion type 171
  bellows 172
  clearance 172
  stuffing box 172
  o-rings 165
    operation 167
    installation 167
  lip type 168-169
  operation 169
  installation 169
Series turbocharging 250
Service indicator, air cleaning system 233
Smoke colour chart 279
Speed droop 537
Squish 28
Sulphur content (of fuel), see Fuel, sulphur content
Swept volume 4
Tangential ports 31
Testing an engine 288
Thermal efficiency 8, 31, 33
Thermostart 182
Timing belt 137
  removal-installation 153
Timing gears 136
Torque 3, 6, 7, 282, 294
Torque control 539
Torque rise 537
Turbocharger 241
  constant pressure type 243
  construction 241
  controls 249
  operation 241
  overhaul 253
  pulse type 242
  service 252
  shutdown procedure 251
  wastegate 249
Turbocharging 241
  advantages of 245
Turbocompounding 241
Turbulence 28, 37
Two-stroke cycle 14-17
Uniflow scavenging 16
Unit injector 338
  Caterpillar 459
  Detroit Diesel 515
  Vacuator valve 231
  Valve 38
    head height 57
    heat dissipation 40
    lapping 56
    operation 38
    refacing 52
    service 48
    synchro-seating 55
  Valve bridge 140
    adjustment 151-152
    wear evaluation 149
  Valve clearance 149
    adjustment 150-151
  Valve guides 42
    service 47
  Valve overlap 13, 143
  Valve rocker levers and shaft 148
    inspection 149
  Valve rotator 43
    service 51
  Valve seat 40
    seat grinding 54
    service 49
    width 57
  Valve spring 41
    installation 42
    service 50
  Valve timing 140
    diagram 141
    two-stroke 143
  Valve train components 136
    toothed drive belt 137
    service 144
  Vibration damper 94
    rubber type 94
    service 107, 108
    viscous type 95
  Viscometer 186
  Viscosity 186
    index (of oil) 198
  Viscosity, scales of measurement 198
  Volatile fuel 183
  Volumetric efficiency 4, 229
  Wastegate (Turbocharger) 249
  Water content (of fuel), see Fuel, water content
  Watt 1
  Wax (in fuel) 186
  Welsh plug 60, 81
  Woodward SG governor 557
  Work 1