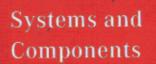
BOSCH



Automotive Technology

## Diesel-Engine Management



New: Unit Pump/Unit Injector

3rd Edition





AUTOMOTIVE A engineer



## **Basics**

- 10 Areas of use for diesel engines
- 10 Suitability criteria
- 10 Applications
- 14 Engine characteristic data
- 16 Basic principles of the diesel engine
- 16 Method of operation
- 19 Torque and power output
- 20 Engine efficiency
- 23 Operating statuses
- 27 Operating conditions
- 30 Fuel-injection system
- 31 Combustion chambers
- 34 Diesel fuels
- 38 Alternative fuels

## Air supply

- 40 Cylinder-charge control systems
- 40 Overview
- 41 Intake air filters
- 44 Swirl flaps
- 44 Turbochargers and superchargers
- 55 Exhaust-gas recirculation

## Diesel fuel injection

- 56 Basic principles of diesel fuel injection
- 56 Mixture distribution
- 58 Start of injection and delivery
- 60 Injected-fuel quantity
- 61 Injection characteristics
- 66 Injection pressure
- 67 Injection direction and number of injection jets
- 68 Overview of diesel fuel-injection systems
- 68 Requirements
- 70 Designs

- 76 Fuel supply system (low-pressure stage)
- 76 Fuel tank
- 76 Fuel lines
- 77 Diesel fuel filter
- 78 Fuel-supply pump
- 80 Distributor tube
- 81 Low-pressure pressurecontrol valve
- 81 ECU cooler
- 81 Fuel cooler
- 82 Supplementary valves for in-line fuel-injection pumps
- 84 Overview of in-line fuelinjection pump systems
- 84 Areas of application
- 84 Types
- 85 Design
- 85 Control
- 88 Presupply pumps for inline fuel-injection pumps
- 88 Applications
- 89 Design and method of operation
- 91 Manual priming pumps
- 91 Preliminary filter
- 91 Gravity-feed fuel-tank system
- 92 Type PE standard in-line fuel-injection pumps
- 93 Fitting and drive system
- 93 Design and method of operation
- 102 Design variations
- 112 Type PE in-line fuel-injection pumps for alternative fuels
- 113 Operating in-line fuelinjection pumps
- 114 Governors and control systems for in-line fuel-injection pumps
- 114 Open and closed-loop control
- 116 Action of the governor/ control system

- 116 Definitions
- 117 Proportional response of the governor
- 118 Purpose of the governor/ control system
- 121 Types of governor/ control system
- 126 Overview of governor types
- 132 Mechanical governors158 Calibration devices
- 100 Cambration devices
- 171 Type PNAB pneumatic shutoff device
- 172 Timing devices
- 174 Electric actuator mechanisms
- 176 Control-sleeve in-line fuel-injection pumps
- 177 Design and method of operation
- 180 Overview of distributor fuel-injection pump systems
- 180 Areas of application
- 180 Designs
- 182 Helix and port-controlled systems
- 184 Solenoid-valve-controlled systems
- 188 Helix and port-controlled distributor injection pumps
- 189 Applications and installation
- 191 Design
- 194 Low-pressure stage
- 197 High-pressure pump with fuel distributor
- 206 Auxiliary control modules for distributor injection pumps
- 206 Overview
- 208 Governors
- 215 Timing device
- 218 Mechanical torque-control modules
- 231 Load switch
- 231 Potentiometer

232	Delivery-signal sensor		Unit pump (UP)	335	Helix and-Port-controlled
233	Shutoff devices		Design and construction		axial-piston distributor pumps
234	Electronic Diesel Control	290	Unit pump for large-size	336	Solenoid-valve-controlled
237	Diesel-engine immobilizers		engines		axial-piston and radial- piston distributor pumps
238	Solenoid-valve controlled	- 292	Overview of common-rail	337	Common Rail System (CRS)
	distributor injection pumps,		system	338	Unit Injector System (UIS)
238	Areas of application	292	Areas of application		for passenger cars
238	Designs	292	Design	339	Unit Injector System (UIS)
240	Fitting and drive system	293	Method of operation		and Unit Pump System (UPS)
242	Design and method	296	System diagram for cars		for commercial vehicles
	of operation	298	System diagram for	340	Application-related
244	Low-pressure stage		commercial vehicles		adaptation of car engines
246	High-pressure stage of			344	Application-related adaptation
	the axial-piston distributor	300	High-pressure		of commercial-vehicle engines
	injection pump		components of	349	Calibration tools
250	High-pressure stage of the		common-rail system		
	radial-piston distributor	300	High-pressure pump	352	Sensors
	injection pump		(pressure generation)	352	Automotive applications
254	Delivery valves	305	Fuel rail (high-pressure	353	Temperature sensors
255	High-pressure solenoid		accumulator)	354	Micromechanical pressure
	valve	308	Nozzle (fuel injection)		sensors
256	Injection timing adjustment			357	Rail-pressure sensors
262	Electronic control unit	312	Nozzles	358	Inductive engine-speed
263	Summary	314	Pintle nozzles		sensors
		316	Hole-type nozzles	359	Rotational-speed (rpm)
264	Overview of discrete	320	Future development		sensors and incremental
	cylinder systems		of the nozzle		angle-of-rotation sensors
264	Single-plunger fuel-injection			360	Hall-effect phase sensors
	pumps PF	322	Nozzle holders	362	Half-differential short-
266	Unit injector system (UIS)	324	Standard nozzle holders		circuiting-ring sensors
	and unit pump system (UPS)	325	Stepped nozzle holders	364	Accelerator-pedal sensors
270	System diagram of UIS	326	Two-spring nozzle holders	366	Hot-film air-mass meter HFM5
	for cars	327	Nozzle holders with	368	LSU4 planar broad-band
272	System diagram of UIS/UPS		needle-motion sensors		Lambda oxygen sensors
	for commercial vehicles				
		328	High-pressure lines	370	Electronic Control Unit
274	Single-plunger fuel-	328	High-pressure connection		(ECU)
	injection pumps PF		fittings	370	Operating conditions
274	Design and method	329	High-pressure delivery lines	370	Design and construction
	of operation			370	Data processing
276	Sizes	Ele	ctronics		
				376	Open and closed-loop
278	Unit Injector (UI)	332	Electronic Diesel Control		electronic control
278	Installation and drive		(EDC)	376	Open and closed-loop
279	Design and construction	332	Requirements		electronic control
282	Operating concept	332	System overview	376	Data processing (DP)

333 System structure334 In-line fuel-injection pumps

286 High-pressure solenoid

valve

378 Data exchange with

other systems

controlled distributor

injection pumps

380	Fuel-injection control	440	Nozzle tests	Bac	kground information
389	Lambda closed-loop-control	442	Emissions measurement		
	for passenger-car diesel		concept	13	History of the diesel engine
	engines	444	Turbidity testing	15	Diesel aircraft engines
395	Further special adaptations				of the 1920s and 30s
395	Port-and-helix-controlled	Die	sel exhaust gases	33	M System
	fuel-injection systems:			54	Pressure-wave
	Triggering	446	Exhaust emissions		superchargers
398	Solenoid-valve-controlled	446	Overview	75	History of diesel fuel
	injection systems:	446	Major components		injection
	Triggering	448	Combustion by-products	99	History of in-line
405	Control and triggering of	450	Reduced emissions		fuel-injection pumps
	the remaining actuators			103	1978 diesel speed records
406	Substitute functions	452	Exhaust-gas treatment	115	History of the governor
407	Torque-controlled		systems	202	Off-road applications
	EDC systems	452	Diesel oxidation-type	205	Diesel records in 1972
	-		catalytic converter	207	History of the mechanically
410	Data transfer between	452	Particulate filter		controlled distributor
	automotive electronic	453	NO <sub>X</sub> accumulator-type		injection pump from Bosch
	systems		catalytic converter	239	Family tree of Bosch
410	System overview	455	SCR principle		electronically controlled
410	Serial data transfer (CAN)	455	Combination systems		distributor injection pumps
415	Prospects			241	1998 Diesel Records
710					
710	'	456	Emissions-control		The history and the future
	Actuators	456	Emissions-control legislation		The history and the future of the unit injector (UI)
416	·			285	•
416	Actuators	456	legislation	285	of the unit injector (UI)
<b>416</b> 416	Actuators Electropneumatic	456 458	legislation Overview	285 313	of the unit injector (UI) Dimensions of diesel
<b>416</b> 416	Actuators Electropneumatic converters Continuous-operation	456 458 462	legislation Overview CARB legislation (Cars/LDT)	285 313 321	of the unit injector (UI) Dimensions of diesel fuel-injection technology
<b>416</b> 416 417	Actuators Electropneumatic converters	456 458 462 464	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT)	285 313 321	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology
<b>416</b> 416 417	Actuators Electropneumatic converters Continuous-operation braking systems Fan control function	456 458 462 464	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT)	285 313 321 331	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the
<b>416</b> 416 417	Actuators Electropneumatic converters Continuous-operation braking systems	456 458 462 464 467	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation	285 313 321 331 348	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system
416 416 417 417 418	Actuators Electropneumatic converters Continuous-operation braking systems Fan control function Start-assist systems	456 458 462 464 467	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs)	285 313 321 331 348	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench
416 416 417 417 418	Actuators Electropneumatic converters Continuous-operation braking systems Fan control function	456 458 462 464 467	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation	285 313 321 331 348 363	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on
416 416 417 417 418 Sei	Actuators Electropneumatic converters Continuous-operation braking systems Fan control function Start-assist systems	456 458 462 464 467	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles)	285 313 321 331 348 363	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines
416 416 417 417 418 Sei 420	Actuators  Electropneumatic converters  Continuous-operation braking systems Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis	456 458 462 464 467 468	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles)	285 313 321 331 348 363 375	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are
416 416 417 417 418 <b>Set</b> 420 420	Actuators  Electropneumatic converters  Continuous-operation braking systems  Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis Operating concept	456 458 462 464 467 468	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation	285 313 321 331 348 363 375	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU
416 416 417 417 418 <b>Set</b> 420 420	Actuators  Electropneumatic converters  Continuous-operation braking systems Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis	456 458 462 464 467 468 469	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation	285 313 321 331 348 363 375 379	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word
416 416 417 417 418 <b>Se</b> l 420 420 423	Actuators  Electropneumatic converters  Continuous-operation braking systems  Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis Operating concept	456 458 462 464 467 468 469 471	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation (commercial vehicles) US test cycles	285 313 321 331 348 363 375 379 394	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word "Electronics" come from?
416 417 417 418 Sei 420 420 423 424	Actuators  Electropneumatic converters  Continuous-operation braking systems Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis Operating concept On-Board-Diagnosis (OBD)	456 458 462 464 467 468 469 471 472 474	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation (commercial vehicles)	285 313 321 331 348 363 375 379 394 429	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word "Electronics" come from? Race-Frucks
416 417 417 418 Sei 420 423 424 424	Actuators  Electropneumatic converters  Continuous-operation braking systems Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis Operating concept On-Board-Diagnosis (OBD)  Service technology	456 458 462 464 467 468 469 471 472 474	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation (commercial vehicles) US test cycles European test cycle	285 313 321 331 348 363 375 379 394 429 449	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word "Electronics" come from? Race-Frucks Global service
416 417 417 418 Sei 420 420 423 424 424 424	Actuators Electropneumatic converters Continuous-operation braking systems Fan control function Start-assist systems rvicing and repairs  Electronic diagnosis Operating concept On-Board-Diagnosis (OBD)  Service technology Overview	456 458 462 464 467 468 469 471 472 474 475	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation (commercial vehicles) US test cycles European test cycle Japanese test cycles	285 313 321 331 348 363 375 379 394 429 449	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word "Electronics" come from? Race-Fucks Global service Ozone and smog
416 417 417 418 Sei 420 420 423 424 424 424	Actuators  Electropneumatic converters  Continuous-operation braking systems Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis Operating concept On-Board-Diagnosis (OBD)  Service technology Overview Testing EDC systems	456 458 462 464 467 468 469 471 472 474 475	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation (commercial vehicles) US test cycles European test cycle Japanese test cycles for cars and LDTs	285 313 321 331 348 363 375 379 394 429 449	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word "Electronics" come from? Race-Fucks Global service Ozone and smog
416 417 417 418 Sei 420 423 424 424 426 430	Actuators  Electropneumatic converters Continuous-operation braking systems Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis Operating concept On-Board-Diagnosis (OBD)  Service technology Overview Testing EDC systems Fuel-injection pump test benches	456 458 462 464 467 468 469 471 472 474 475	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation (commercial vehicles) US test cycles European test cycle Japanese test cycles for cars and LDTs Test cycles for commercial	285 313 321 331 348 363 375 379 394 429 449	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word "Electronics" come from? Race-Fucks Global service Ozone and smog
416 417 417 418 Sei 420 423 424 424 426 430	Actuators  Electropneumatic converters Continuous-operation braking systems Fan control function Start-assist systems  rvicing and repairs  Electronic diagnosis Operating concept On-Board-Diagnosis (OBD)  Service technology Overview Testing EDC systems Fuel-injection pump	456 458 462 464 467 468 469 471 472 474 475	legislation Overview CARB legislation (Cars/LDT) EPA regulations (Cars/LDT) EU regulations (Cars/LDT) Japanese legislation (cars/LDTs) US legislation (commercial vehicles) EU legislation (commercial vehicles) Japanese legislation (commercial vehicles) US test cycles European test cycle Japanese test cycles for cars and LDTs Test cycles for commercial vehicles	285 313 321 331 348 363 375 379 394 429 449	of the unit injector (UI) Dimensions of diesel fuel-injection technology High-precision technology Caviation in the high-pressure system Engine test bench Measured variables on diesel engines Very severe demands are made on the ECU Where does the word "Electronics" come from? Race-Fucks Global service Ozone and smog

482 Index of technical terms482 Technical terms

488 Abbreviations