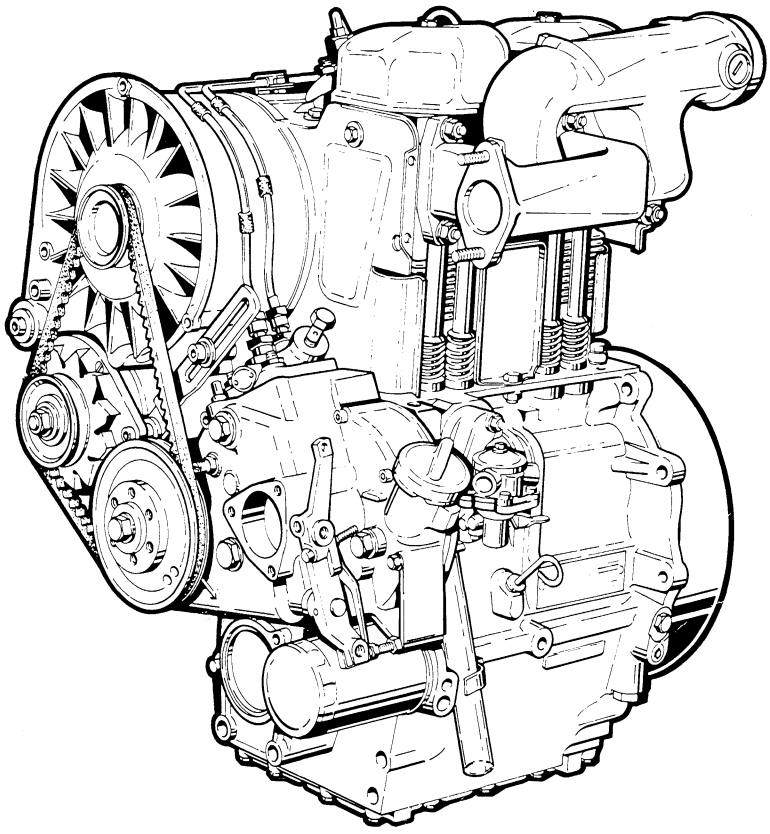
Workshop Manual

KHD
DEUTZ

291 1921

01/1987

FL 511/W



WORKSHOP MANUAL
for
Air-cooled DEUTZ DIESEL Engines

FL 511/W

Printed material no. 291 1921

Date of issue 01/1987

FOREWORD

This Workshop Manual informs our customers and Service partners about repair and adjustment work on the DEUTZ diesel engine. It is presumed that this work will be carried out by qualified personnel.

This Manual has been made up in a manner which ensures quick visual comprehension of the contents. This is achieved by illustrations and graphic symbols as substitute for the respective text. This layout permits universal use, because the illustrations and symbols are also largely understood by those being unable to read and write.

Aspects of operation and maintenance are not dealt with in this Manual; they are contained in the Engine Operation Manual.

This Workshop Manual is not regularly updated. Any engineering changes having been introduced in the meantime will be considered in the next issue. Therefore, please refer to the Technical Circulars where engineering changes are announced when appropiate.

General:

- This Workshop Manual has been prepared using our best knowledge and experience, taking into account safety and environmental aspects.

- It has to be ensured that everyone concerned with repair or adjustment work on the engine has this Workshop Manual available, reads it and understands it.

- It has to be ensured that all equipment, hand and special tools required for proper execution of repair work are in good condition.

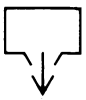
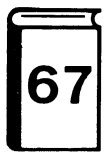
- Failure to comply with this Workshop Manual may result in malfunction of the engine, short lifetime of components, personal injury or damage to porperty and environment for which we take nor responsiblity.

- Engine components such as springs, clips, flexible retainining rings, electric equipment, pipes, etc. involve a risk of damage or personal injury if handled in an improper way. It is therefore essential that no one attempts to do any work on the engine unless he has the necessary experience of the various tools, materials and methods.

- To ensure best efficiency, reliability and lifetime of the engine and its components, only original spare parts may be used for the repair.

Key to Symbols

	**Disassembly** of assembly groups
	**Reassemble** to form assembly group
	**Remove** obstructing parts
	**Reinstall – Remount** parts which had obstructed disassembly
	**Attention! Important notice!**
	**Check – Adjust** e. g. torque, dimensions, pressures, etc.
	**Special tool**
	**Note direction of installation**
	**Visual inspection**
	**Possibly still serviceable** Renew if necessary
	**Renew at each reassembly**
	**Unlock – Lock** e. g. split pin, locking plate, etc.
	**Lock – Adhere** e. g. with liquid sealant

	**Guard against personal injury** Indication of hazard
	**Guard against material damage** Damage to parts
	**Prop up – Support – Hold**
	**Oil**
	**Grease**
	**Mark** before disassembly, observe marks when reassembling
	**Balance** Eliminate any imbalance
	**Filling – Topping up – Refilling** e. g. oil, cooling water, etc.
	**Drain off** e. g. oil, cooling water, etc.
	**Loosen – Release** e. g. loosening a clamping device
	**Tighten – Clamp** e. g. tightening a clamping device
	**Vent**
	**Machining process**
	See Technical Data (For inst. 67 as indication of the line)

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1. SPECIFICATION DATA

General engine data

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
1	Total piston displacement cm^3	825		1650	
2	Working cycle	Four-stroke diesel			
3	Combustion system	Direct injection W = 2-stage combustion system			
4	Bore mm	100			
5	Stroke mm	105			
6	Weight of engine according to VDMA kg	116		155	
7	Direction of rotation	When facing flywheel left counterclockwise			
8	Rated speed max. 1/min	3000			
9	Minimum idle speed 1/min	950 ± 50			
10	Compression ratio	17 : 1 FL 511 W = 19 : 1			
11	Compression pressure bar	29 - 31			
12	Firing order	———		2 - 1	
13	Dimensions of engine with oil bath air cleaner and fuel filter				
14	Overall length mm	459,5		571	
15	Overall width mm	525		525	
16	Overall height mm	694		731	

Fuel injection system

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
17	Fuel injection pump Make	Bosch			
18	Pressure for testing tightness of relief valve (drop to140 bar in a minute permiss) bar	150			
19	Minimum pressure that must be attained with the injection pump element (with about 5 rotations of crankshaft) bar	300			
20	Governor Make	Deutz			
21	Injection nozzle Bosch	DLLA 149 S 774 FL 511 W = DNOSD 165			
22	Opening pressure (checking injector for re-use) bar	175^{+8} FL 511 W = 115^{+8}			
23	Opening pressure (new condition) bar	180^{+8} FL 511 W = 120^{+8}			
24	Commencement of del. before TDC in °crankshaft rota.				
25	Engines without advance unit degree / 1/min	24° FL 511 W = 20°			
26	Engines with advance unit degree/1/min	———			

Fuel injection system

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
27	Advance unit degree	———			
28	Dimension of Injection Pump mm	$82,6^{\pm 0,1}$			
29	Distance between the governor head and the crankcase mm	84,7 - 85,7			
30	Diameter of balls for the governor's thrust bearing mm	8			
31	No. of balls	19			
32	Speed adjusting shaft Axial clearance mm	0,2 - 1,1			

The commencement of injection expressed in degrees of crank angle (^{o}Kw) can be translated into a length "L" in mm marked on the V-belt pulley (flywheel) as follows

$$L = \frac{d \cdot 3,14 \cdot {}^{o}Kw}{360^{o}}$$

Cylinder unit

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
33	Cylinder head				
34	Valve guide Outside diameter mm	$15,0^{+0,056}_{+0,045}$			
35	Number of oversizes	2			
36	Each oversize mm	$0,25^{+0,056}_{+0,045}$			
37	Bore in cylinder head mm	$15,0^{+0,011}_{0}$			
38	Number of oversizes	2			
39	Each oversize mm	$0,25^{+0,011}_{0}$			
40	Valve guide (pressed in) Inside diameter mm	$8,0^{+0,015}_{0}$			
41	Valve stem Diameter Inlet mm	$7,96^{0}_{-0,015}$			
42	Valve stem Diameter Exhaust mm	$7,94^{0}_{-0,02}$			
43	Valve stem clearance Inlet normal mm	0,04 - 0,07			
44	Inlet Limit value mm	0,15			
45	Exhaust normal mm	0,06 - 0,095			
46	Exhaust Limit value mm	0,2			
47	Valve seating ring Inlet outside diameter, nominal mm	$45,66^{0}_{-0,02}$			
48	Number of oversizes	3			
49	Each oversize mm	$0,1^{0}_{-0,02}$			
50	Exhaust outside diameter, nominal mm	$40,16^{0}_{-0,02}$			
51	Number of oversizes	3			
52	Each oversize mm	$0,1^{0}_{-0,02}$			

Cylinder unit

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
53	Bore in cylinder head Inlet mm	$45{,}5\ ^{+0{,}025}_{0}$			
54	Exhaust mm	$40{,}0\ ^{+0{,}025}_{0}$			
55	Valve tulip Ø Inlet mm	$43{,}0 \pm 0{,}1$			
56	Valve tulip Ø Exhaust mm	$37{,}0 \pm 0{,}1$			
57	Valve seat width Inlet mm	$1{,}5\ ^{+0{,}6}_{0}$			
58	Exhaust mm	$1{,}5\ ^{+0{,}6}_{0}$			
59	Seat angle - degree Inlet	45°			
60	Exhaust degree	45°			
61	Rim thickness Inlet mm	$1{,}0\ ^{0}_{-0{,}2}$			
62	Exhaust mm	$1{,}8\ ^{0}_{-0{,}2}$			
63	Wear limit Inlet mm	0,5			
64	Exhaust mm	0,7			
65	Distance valve disc/ Cylinder head sealing surface mm	5,9			
66	Limit value mm	5,2			
67	Valve clearance when engine is cold Inlet mm	0,15			
68	Exhaust mm	0,15			
69	After repairs to cylinder unit Inlet mm	0,15			
70	Exhaust mm	0,15			
71	Clearance between valve rockers and the cams of the decompression gear Coarse adjustment mm	—			

Cylinder unit

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
72	Setting dimension for decompression device mm	$60,3\ ^{0}_{-0,2}$			
73	Maximum distance between cylinder head bottom and cylinder head joint mm	6,3			
74	Limit value mm	5,8			
75	Valve spring				
76	Windings total	7			
77	Length unloaded, normal mm	59			
78	Length unloaded Fatigue limit mm	56			
79	Cylinder head bolts				
80	Length mm	$188\ ^{\pm 0,5}$			
81	max. length mm	189,5			
82	Cylinder				
83	Bore normal mm	$100\ ^{+0,22}_{0}$			
84	Bore wear limit mm	1) 0,15 2) 0,10			
85	Number of over-sizes	2			
86	Each oversize mm	$0,5\ ^{+0,22}_{0}$			
87	Nominal distance between cylinder a. engine housing mm	—			
88	Piston				
89	Diameter normal mm	FL 511 = $99,96\ ^{\pm 0,009}$		FL 511 W = $99,97\ ^{\pm 0,009}$	

1) Reversing point, 1st piston ring;

2) Remaining range of stroke;

Cylinder unit

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
90	Number of oversizes	2			
91	Each oversize mm	$0,5^{+0,009}_{-}$			
92	Distance between piston and cylinder head mm	1,0 - 1,2			
93	Bore for piston pin mm	$35,0^{+0,010}_{+0,004}$			
94	Piston pin diameter mm	$35,0^{0}_{-0,006}$			
95	Piston ring grooves width of 1st groove (based on) mm	$2,7^{+0,002}_{-}$ (Ø 97 - 0,16)			
96	Width of 2nd and 3rd grooves mm	$2,5^{+0,10}_{+0,08}$			
97	Width of scraper ring groove mm	$5,0^{+0,05}_{+0,03}$			
98	Piston rings				
99	Side clearance 1st compression ring mm	0,105 - 0,145			
100	Limit value mm	0,5			
101	2nd compression ring mm	0,090 - 0,122			
102	Limit value mm	0,3			
103	3rd compression ring mm	—			
104	Limit value mm	—			
105	Slotted oil ring mm	0,040 - 0,072			
106	Limit value mm	0,15			
107	Gap compression rings, normal mm	0,35 - 0,55			
108	Limit value mm	0,8			

Cylinder unit

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
109	Gap - slotted oil control rings normal mm	0,25 - 0,40			
110	Limit value mm	0,8			
111	Connecting rod				
112	Hole for gudgeon pin bushing mm	$38,0\ ^{+0,020}_{0}$			
113	Autside diameter gudgeon pin bushing mm	$38,080\ ^{0}_{-0,03}$			
114	Inside diameter, pressed in mm	$35\ ^{+0,036}_{+0,080}$			
115	Gudgeon pin clearance in gudgeon pin bush mm	0,036 - 0,086			
116	Limit value mm	0,15			
117	Big-end bearing bore mm	$57,0\ ^{+0,025}_{0}$			
118	Bearing shell Nominal inside diameter mm	$52,04\ ^{+0,033}_{0}$			
119	Number of undersizes	3			
120	Each undersize mm	$0,5\ ^{+0,033}_{0}$			
121	Nominal wall thickness mm	$2,476 \pm 0,005$			
122	Number of oversizes	3			

Motion parts

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
123	Each oversize mm	0,5			
124	Width of bearing mm	$25^{\ 0}_{-0,3}$			
125	Width of connecting rod mm	$34,0^{-0,170}_{-0,232}$			
126	Big-end bearing clearance				
127	Radial clearance normal mm	0,05 - 0,108			
128	Radial clearance limit value mm	0,15			
129	Side clearance normal mm	0,170 - 0,271			
130	Side clearance limit value mm	0,6			
131	Camshaft				
132	Camshaft main bearing bore spur gear cap mm	—			
	Crankcase mm	$52^{+0,030}_{\ 0}$			
133	Camshaft bearing bushing Nominal internal diameter mm	$48,01^{+0,054}_{\ 0}$			
134	Journal Camshaft	$48^{-0,025}_{-0,050}$			
135	Side clearance of camshaft mm	0,25 - 0,6			
136	Limit value mm	0,8			
137	Radial clearance of camshaft mm	1) 0,035 - 0,114 2) 0,04 - 0,094			
138	Radial clearance limit value (Replacement is governed by oil pressure) mm	0,2			
139	Valve cams Inlet mm	$8,0 \pm 0,1$			
140	Exhaust mm	$8,0 \pm 0,1$			
141	Timing data check				
142	with valve clearance mm	0,15			
143	Inlet opens before TDC degree	32° 30'			

1) Blower end, 2) Flywheel end,

Motion parts,

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
144	Inlet closes after BDC degree	$59^{\circ}\ 30'$			
145	Exhaust opens before BDC degree	$71^{\circ}\ 30'$			
146	Exhaust closes after TDC degree	$32^{\circ}\ 30'$			
147	Main bearing bore Drive shaft Spur gear cover mm	$37\ ^{-0,029}_{-0,045}$			
	Crankcase mm	$62\ ^{-0,026}_{-0,045}$			
148	Crankshaft				
149	Crankpin Diameter normal mm	$52,0\ ^{-0,010}_{-0,029}$			
150	Number of undersizes	3			
151	Each undersize mm	$0,5\ ^{-0,010}_{-0,029}$			
152	Pin width mm	$34\ ^{+0,039}_{0}$			
153	Out-of-roundness wear limit mm	0,01			
154	Hardness normal HRc	55 - 61			
155	Limit value HRc	50			
156	Shaft journal for crankshaft bearing				
157	Diameter normal mm	$64,0\ ^{-0,010}_{-0,029}$			
158	Number of undersizes	3			
159	Each undersize mm	$0,5\ ^{-0,010}_{-0,029}$			
160	Out-of-roundness wear limit mm	0,01			
161	Width of journal mm	$33,5\ ^{0}_{-0,15}$			
162	Hardness normal HRc	55 - 61			
163	Limit value HRc	50			
164	Locating bearing				
165	Bore for main bearing mm	$69,0\ ^{+0,019}_{0}$			

Motion parts

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
166	Bearing bush - Inside diameter normal mm	$64{,}05\ ^{+0{,}039}_{0}$			
167	Number of undersizes	3			
168	Each undersize mm	$0{,}5\ ^{+0{,}039}_{0}$			
169	Nominal wall thickness mm	$2{,}475 \pm 0{,}005$			
170	Number of oversizes	3			
171	Each oversize mm	0,25			
172	Radial clearance normal mm	0,06 - 0,118			
173	Radial clearance limit value (Replacement is governed by oil pressure) mm	0,18			
174	End clearance of front crankshaft bush mm	$1{,}7\ ^{0}_{-0{,}3}$			
175	Back allowance of crankshaft bush in end shields mm	$1{,}7\ ^{0}_{-0{,}3}$			
176	Shaft journal (Bearing bracket)				
177	Nominal diameter mm	———		$60\ ^{-0{,}010}_{-0{,}029}$	
178	Number of undersizes	———		3	
179	Each undersize mm	———		$0{,}5\ ^{-0{,}010}_{-0{,}029}$	
180	Out-of-roundness wear limit mm	———		0,01	
181	Pin width mm	———		$40{,}0 \pm 0{,}1$	
182	Radius of fillet mm	———		$4{,}5\ ^{0}_{-0{,}2}$	

Motion parts

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
183	Hardness normal HRc	———		55 - 61	
184	Hardness limit value HRc	———		50	
185	Locating bearing				
186	Bore for bearing mm	———			
187	Bore in bearing block mm	———		$66\ ^{+0,019}_{0}$	
188	Bearing shell Inside diameter normal mm	———		$60,04\ ^{+0,043}_{0}$	
189	Number of undersizes	———		3	
190	Each undersize mm	———		$0,5\ ^{+0,043}_{0}$	
191	Nominal wall thickness mm	———		$2,979\ ^{+0,006}_{-}$	
192	Number of oversizes	———		3	
193	Each oversize mm	———		0,25	
194	Radial clearance normal mm	———		0,05 - 0,112	
195	Radial clearance limit value (Replacement is governed by oil) mm	———		0,18	
196	Stop ring				
197	Stop ring thickness mm	$2,985\ ^{0}_{-0,05}$			
198	Number of oversizes	3			
199	Each oversize mm	0,25			

Motion parts

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
200	Bearing width Outside distance of stop rings mm	—			
201	Side clearance normal mm	0,1 - 0,3		0,2 - 0,4	
202	Limit value mm	0,4		0,5	
203	Thrust washers (Blower side) Nominal inside diameter mm	—			
204	Outside diameter mm	—			
205	Thrust washer (Flywheel) Nominal inside diameter mm	—			
206	Outside diameter mm	—			
207	Mass balancing gear	—			
208	Backlash mm	—			

Lubrication system,

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
209	Lubrication oil pump				
210	Pump speed / Motor speed 1/min	2546 / 3000			
211	Delivery rate ± 10 % at 6 bar 60°C, oil SAE 20 l/h	600		1100	
212	Width of delivery	- 0,005 8,0 - 0,020		- 0,006 14,0 - 0,024	
213	Side clearance of delivery gears normal mm	0,03 - 0,067		0,038 - 0,083	
214	Limit value mm	0,1			
215	Crankshaft gear mm	0,008 - 0,216			
216	Limit value mm	—			
217	Clearance of delivery gears in the housing mm	0,07 - 0,135			
218	Limit value mm	—			
219	Quantity of lube oil in ltr.				
220	Motor oil Initial fill	see Instruction Book – Correct oil filling is governed by dipstick marks			
221	Motor oil Refill	see Instruction Book - Correct oil filling is governed by dipstick marks			
222	Lube oil pressure in bar				
223	In low idling minimum	0,5			
224	Safety valve on lube oil pump	—			
225	By-pass valve on oil cooler	—			

Lubrication system,

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
226	By-pass valve on lube oil filter	———			
227	By-pass valve on entire filter	———			
228	Pressurestat	6 - 10			
229	Grade of lubricant to be used	siehe Betriebsanleitung see Instruction Book cf. Manuel d'Instructions ver Manual de Instrucciones			

After-tightening angles and torque,

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
230	After-tightening angles in degrees	Preloading a) 15 Nm ;	b) 30 Nm ;		c) 40 Nm
231	Cylinder head bolts	c) $45^\circ + 45^\circ + 45^\circ + 30^\circ = 165^\circ$			
232	Nuts for rocker arm bracket	28 Nm			
233	Nut for rocker arm pin	40Nm			
234	Bolt for rocker chamber cover	7 - 15 Nm			
235	Bolt for rocker cover with decompression device	20 - 22 Nm			
236	Screws for governor leaf spring	10 Nm			
237	Protective sleeve for damping spring	26,5 - 33,5 Nm			
238	Bolts for tappet bridge	———			
239	Main bearing bolts (bearing bracket)	b) $30^\circ + 30^\circ = 60^\circ$			
240	Fastening bolts for bearing bracket in crankcase	b) $30^\circ + 30^\circ = 60^\circ$			
241	Big-end bolts	b) $30^\circ + 60^\circ = 90^\circ$			
242	Bolts for cast rocker chamber	———			
243	Flywheel bolts	b) $30^\circ + 60^\circ = 90^\circ$			
244	Flywheel nuts	———			
245	Counter-weight bolts	b) 60°			
246	Anti-fatigue bolt for cooling blower	a) M8x80 DIN 931 - 10.9 $= 45^\circ$ b) M12x135 DIN 931 - 8.8 $= 90^\circ$			
247	Grooved nut - blower	———			
248	Bolt for fan drive	———			
249	Anti-fatigue bolts at the front crankshaft end	———			

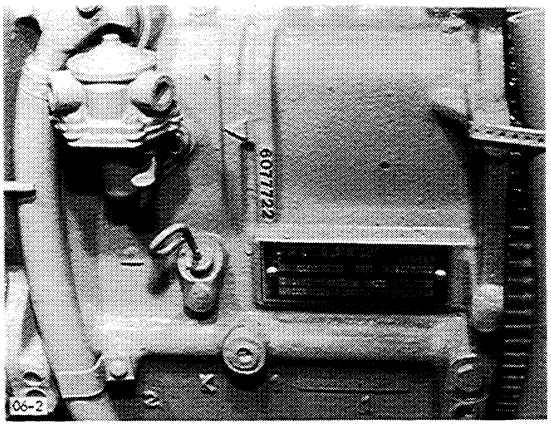
After-tightening angles and torque,

	Designation of type	F1L 511	F1L 511 W	F2L 511	F2L 511 W
250	Bolt(s) for securing vee-belt pulley 1) without PTO 2) with PTO	b) 1) ; 2) = 150° Cheese-head screw > b) 30° + 60° = 90°			
251	Gear bolt on crankshaft	b) 30° + 30° = 60°			
252	Union nut for injector nozzle	60 - 80 Nm			
253	Screw plug in cylinder head	80 - 90 Nm			
254	Injector fastening 1) Screw union 2) Hex. nut	1) 90 - 110 Nm 2) 25 - 30 Nm			
255	Nut on fuel injection pump drive	—			
256	Bolts for injection pump gear or advance unit	—			
257	Cooling blower fastening	b) 60°			
258	Screw connection: V-belt idler pulley	b) 45°			
259	Bearing flange for power take-off at camshaft	35 Nm			
260	Temperature sensor (engine cold)	25 - 30 Nm			
261	Temperature switch	8 Nm			
262	Hydraulic pump drive gear	75 - 85 Nm			
263	Hydraulic pump on front cover	M8 x 30 DIN 933 - 8.8. = 25 Nm M6 x 80 DIN 931 - 10.9 = 14 Nm			
264	Screw union: Oil pump suction pipe	50 Nm			

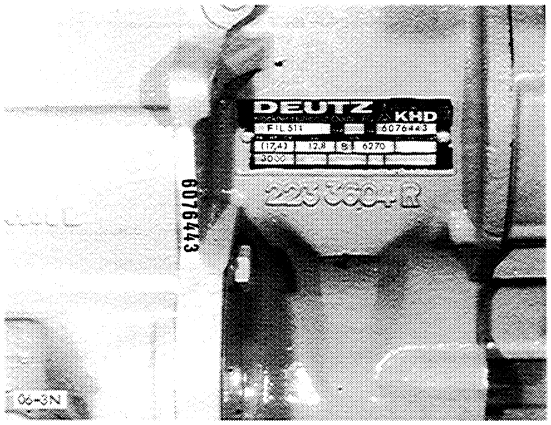
ENGINE SERIAL NUMBERS

The serial No. is stamped both on the maker's nameplate (Fig. 1-1) and the crankcase (Fig. 1-2). Fig. 1-3 shows the plate of the F1L 511 (direct injection).

1-1



1-2



1-3

MAKER'S NAMEPLATE

In addition to the engine serial No., the plate indicates the particular engine model and version respectively. Typical example : F1L 511 / W.

F = High-speed four-stroke
1 = Single-cylinder
L = Air-cooling
5 = Generation No.
11 = Piston stroke in cm (10.5)
W = Two-stage combustion

The engine version without the suffix letter "W" refers to direct injection.

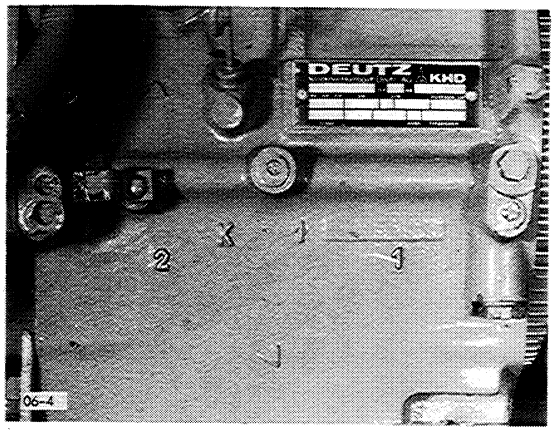
Further data of the nameplate: Rated power in kW (HP) and speed in rev/min. Letter "A" denotes continuous power (with overload capacity), letter "B" denotes intermittent power (w/o overload capacity), both according to DIN 6270.

De-rated industrial engines have an additional rating plate. The rating for automotive engines refers to DIN 70020.

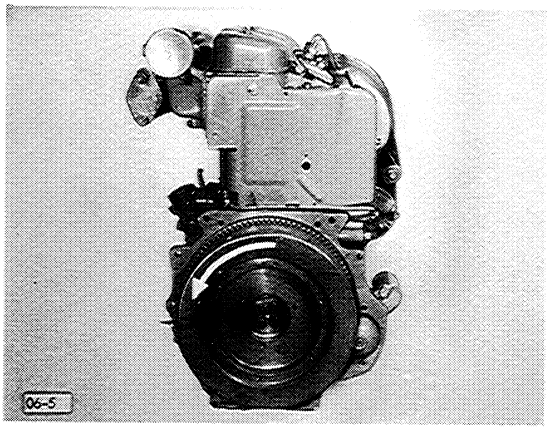
Utmost cleanliness, accuracy etc. are essential prerequisites for carrying out work on the engine.

Cleaning components of the electrical and injection systems call for particular care. For carrying out repairs etc. be sure to use only appropriate tools. See also Section 10 for "SPECIAL TOOLS".

The number of cylinders (F1L or F2L) is marked on the LH side of the crankcase as viewed from the engine's driving end (Fig. 1-4). The crankshaft rotation is counter-clockwise (CCL), likewise as viewed from the driving end.
Fig. 1-5



1-4



1-5

When dismantling the engine, mark the components of the motion parts, timing gears, cylinders and pistons in consecutive order, unless already provided. Again start from the driving end.

Put down removed components carefully to avoid damage. Gauge all wearing parts. Where the wear limits are reached or even exceeded, replace components or overhaul them. Gaskets and washers must be replaced in any case.

For component Nos. see parts list pertaining to your particular engine. Use only genuine Deutz parts. Heavy-duty parts are identified by a special Deutz inspection mark.

If bearings or pistons are defective, inspect crankshaft and connecting rods for cracks, preferably using the magnaflux method. Be sure to trace the cause of such defects. For work on the removed engine, it is recommended to use the swivelling-type assembly stand No. 6066 for double-sided clamping, or No. 6067 for single-sided clamping.

Important:

It is a good plan to entrust difficult work to the local Deutz distributor.