



Power Unit – Diesel/Hydraulic Operation Manual

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Revision History

Rev	Date	Reason
B	01/23/15	Revised format
C	3/19/15	Added Hi/Low option
D		

Description of Change

Rev	Change
B	Combined Hydraulic and Engine Troubleshooting, incorporated Safety Issues into other sections, removed appendix “Metaris Pump”, added Appendix F, removed reference to using lift eyes for lifting entire unit, and added Spare Parts List.
C	Added 1) Hi/Low option, 2) Sentinel system, 3) emergency shut off valve (Figure 6), 4) manifold (Figure 5 & Table 3), 5) hose kit (Figure 17, 18, & 19, Table 19), 6) Depressurization Air System section, and 7) Figures 11 & 12. Renumbered Tables and Figures. Changed 8) number of Table 8 & 12 9) term ‘hydraulic oil’ to hydraulic fluid, 10) cooler p/n from 060015, and 11) BOM Item 1 from TFB914-KIT. Revised Troubleshooting section and Spare Parts List (Table 20). The turbo unit is no longer offered. Updated unit pictures.

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Figure 1: Power unit shown with electric start

Texas International Oilfield Tools (TIOT) offers three (3) styles of Power Units which operate many types of hydraulic equipment. Each unit is mounted on a skid for easy transport and has the following attributes:

Item		Features	
Skid	ASTM A36 steel construction		
	Lift eyes on top to lift basket only		
	Fully welded belly pan		
	Removable drain plug		
	Full length forklift tubes		
	Removable top/basket		
Return Filter on tank	Sight gauge	Dirty element	
		No element	
		Operation OK	
	Full flow return line		

Table 1



Large forces are involved in using this device. Operate this equipment with extreme caution

	Start		Pump
	Air	Electric	
Diesel Engine	TIOT Part No.		
Naturally Aspirated	TFBD914-AIR	TFBD914-ELEC	single stage
Naturally Aspirated	TFBD914-AIR-**-HL	TFBD914-ELEC-**-HL	dual stage

** See Table 3

Table 2

Manifold Options		Pump
V1	Tubing/Casing	40/40
V2	Casing	40/20

Table 3

The Hi/Low (HL) has a naturally aspirated diesel engine and a dual stage (either 40/40 or 40/20) pump, allowing the power unit to operate at a lower flow (gallon per minute) for tubing and a higher for casing. The single stage pump is also offered. All units are available with an air or electric start.

CONVENTIONS




IMPORTANT SYMBOL IDENTIFICATION	
	WARNING to Operators / Users
	CAUTION to Operators / Users
	NOTIFICATION to Operators / Users

Table 4

SAFETY

Texas International's equipment is used and installed in controlled rig environments involving hazardous operations and situations.

All personnel performing installation, operations, repair or maintenance on this Power Unit must have knowledge of rig procedure. All crew in the vicinity of operations should be trained on rig safety and tool operation.

SPECIFICATIONS

Item	Size (inches)			Dry weight (lbs)	Full weight (lbs)
	L	W	H		
Power Unit*	96	52	63	3897	5009

* Turbo adds 415 lbs

Table 5

Item	Power (hp)	Speed (rpm)	Torque (ft/lbs)	Oil/filter change (hrs)	Fuel consumption
Deutz Air Cooled Diesel Engine*	119	2500	255	500**	6 gph***
	85	1500	295		

*Air or Electric Start

** under severe condition - do every 250 hours

*** approximate at maximum output

Table 6

Item	Group type	Volt	Size			Cold cranking amps @ 0F	Cold cranking amps @ 32F	Reserve capacity minutes @ 25 amps
			L	W	H			
Battery*	24	12	10-3/4"	6-3/4"	9"	675	850	115

* Electric Start only

Table 7

Pump						
Stage	Gear	Displacement (cu in/rev)	Mount	Speed (rpm)	Flow rate (GPM)	Max operating pressure
Single	Heavy Duty	6.35	SAE B	2500	67	2500 psi
				1000	27	
Dual*		10.8		2500	117	
				1000	46	

* for Hi/Low units

Table 8

Tanks		Features		Recommended	
Hydraulic	Sight and temperature gauges		Volume (gal)	Working (gal)	operating temp (°F)
	Filtered breather				
	Top access hatch		135	118	100 - 130
	Fully welded steel construction				
Diesel	Top access filler		35	33	N/A
	Fully welded steel construction				

Table 9

Item	Features	Max operating pressure	Min. pressure	Oil flow required
Oil Cooler	Oil/air type	2000 psi	675 psi	3.3 GPM
	Brazed bar & plate construction			
	Oversized for hot climates			
	Adjustable fan speed			
	Low press drop (<18 psi) at max flow			

Table 10

Item	Factory set
Relief valve - adjustable	2500 psi

Table 11

Standard gauges
Output Pressure 0 - 3000 psi oil filled
Tank Temp
Tank Level
Filtration status

Table 12

Optional	Gauges	Voltmeter
		Engine Temp
		Engine Oil Press
		Engine Hour Meter
	Remote Start/Stop	

Table 13



Do not exceed the system's rated pressure or over tighten fittings

INSTALLATION

- 1) Find the best location for the unit – away from hazardous vapors
- 2) place the unit, connect power, and make hydraulic connections
- 3) test the unit for proper operation

The diesel hydraulic power unit requires a location where adequate air flow and exhaust removal are available.



Ensure that ventilation can carry away the exhaust fumes – diesel exhaust can be lethal

It's important to consider hydraulic line losses from size, length and pressure in choosing where to place the unit. The sizes of the hydraulic lines should be large enough to limit friction losses to 300 psi or less. This may mean using hoses larger than the connections on the unit. For connection instructions, see Hydraulic section page 11.



Proper hose connection is required to fully open the check valves in the hose couplings

Ideally, the unit will be located in a non-hazardous location, with excellent ventilation, as close as possible to the equipment to be powered.

Location:

- Requires at least three (3) feet between the oil cooler fan and any wall or obstruction. In the best conditions, the fan will be facing open air
- Ensure power cables are placed where they won't be cut, nicked, or squeezed
- Allow distance around the accessory drive on the front of the engine so personnel can pass easily



The engine develops almost 300 foot-pounds of torque and at 1800 rpm; foreign objects (i.e. loose clothing, long hair, etc.) can be drawn in - with disastrous results

Transport the power unit using **only** the forklift tubes provided shown in Figure 2.



Figure 2



Use top lift eyes, shown in Figure 2, to remove the top basket from the frame/skid – NOT designed to lift the entire skid

If the unit is full of hydraulic fluid the center of mass is approximately in the center of the forklift tubes. If the unit is empty, the center of mass is still between the forklift tubes but biased to the engine end.



Positioning forklift forks in other positions can damage the unit and can be dangerous to personnel

Ensure the unit does not shift or move from its intended location.

HYDRAULIC

The power unit during operation heats the hydraulic fluid. If the reservoir temperature exceeds 150 degrees Fahrenheit (°F), shut down the unit and let it cool. If this happens regularly, have unit repaired.



Be careful not to expose skin to hot hydraulic fluid – it can scald

Time and Temperature Relationship to Severe Burns

Water temperature		Time for a third degree burn to occur
155° F	68° C	1 second
148° F	64° C	2 seconds
140° F	60° C	5 seconds
133° F	56° C	15 seconds
127° F	52° C	1 minute
124° F	51° C	3 minutes
120° F	48° C	5 minutes
100° F	37° C	safe temperature for bathing

Figure 3*

*American Burn Association SCALD INJURY PREVENTION, Educator's Guide

The hydraulic fluid may be under pressures as high as 2500 psi. Fluid can be sprayed some distance, creating a slip hazard. If a leak occurs, shut down the power unit immediately and repair. Hydraulic fluid can irritate the skin – for skin contact, wash and rinse the affected area. If fluid comes in eye contact, use an emergency eyewash or flush with saline solution. If not available, flush with distilled or lastly, tap water. Seek medical attention after flushing.



Avoid the hydraulic fluid spray– it can be injected through the skin at high pressures

The power unit is equipped with Snavite 78 series quick disconnect couplings (or equivalent), one (1) inch for the supply line and one and a quarter (1-1/4) inch for the return line. These couplings contain check valves to prevent the loss of hydraulic fluid during connection and disconnection.



Proper connection is required to fully open the check valves in the couplings

Connect the hoses as follows:

1. Wipe the connections clean as needed to remove dirt and dust.
2. Connect the one (1) inch pressure hose to the one (1) inch coupling on the unit by engaging the mating coupling halves and forcing the connectors together while rotating the threaded sleeve on the hose connector.
3. Using the same method as above, connect the one and a quarter (1-1/4) inch return hose.



Put the selector switch in Start position to connect hoses



If either the pressure or return fittings are not fully tightened, the check valve will cause a restriction in the flow. This can result in overheating the fluid, poor tool operation and damage to equipment

Hoses, connections and fittings should be chosen carefully so as not to cause excessive restriction. Restriction in a hydraulic system equals pressure drop and pressure drop equals heat. Improper connection or restrictive circuits can cause a serious loss of power and will generate heat uselessly. Choose short, large inside diameter hoses whenever possible over long, skinny ones.



High temperatures decrease the useful life of the hydraulic fluid, the hoses and the seals in the equipment being powered

Low hydraulic fluid level can cause overheating, or in worst cases severe damage to the pump and even the associated tools it's driving. Keep fluid up to at least the

minimum on the sight gauge. Observe the return filtration monitor to be sure it's operating in the green (OK) range. Change the filter if it's not.

Recommended Fluids
Mobil DTE 24
Castrol Hyspin VG 32
Royal Purple Syndraulic 32
Shell Tellus 32
PetroCanada Environ AW 32
ISO viscosity grade 46*

* for warmer climates

Table 14

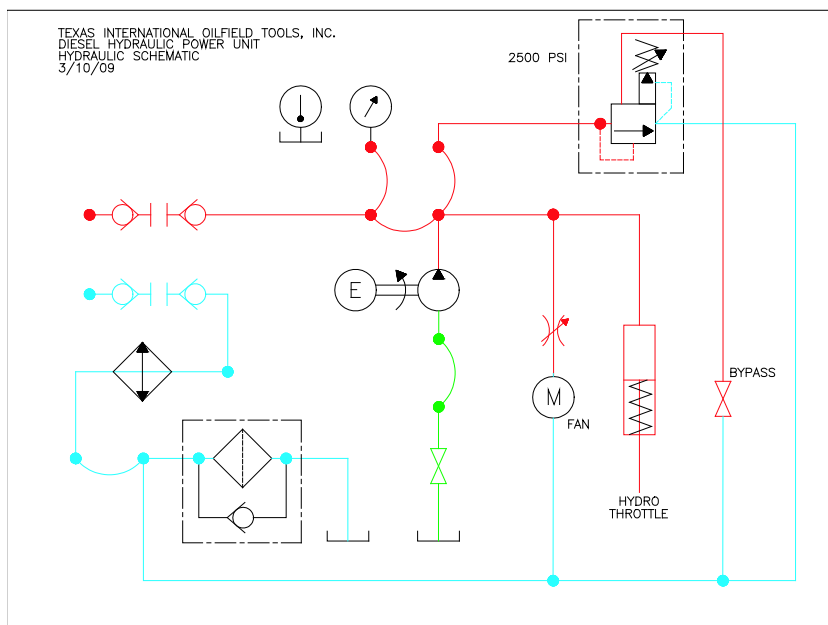


Figure 4 – Standard unit

Color Line	Function
Red	Pressure
Aqua (blue)	Return
Green	Suction

Table 15 – Standard unit

Item No.	Qty	Description
1	1	Manifold Body
2	1	Check Valve
3	1	Relief Style Logic Element
4	1	Flow Control
5	1	2-way, pilot-to-shift directional valve
6	1	Poppet Style Check valve
7	2	Removable Orifice
8	1	Relief Valve
9	1	Logic Element Relief
10	1	SAE -10 Plug
11	2	SAE -8 Plug
12	5	SAE -2 Plug
13	2	SAE -4 Plug

Figure 5 – Hi/Low manifold

OPERATION

On all units, the pump draws hydraulic fluid from the tank and delivers hydraulic fluid up to 2500 psi on the pressure line, adjustable at the relief valve (preset at 2500 psi). See the Adjustment section on page 18 for how to change the relief valve setting. The 2500 psi setting is the maximum recommended output pressure. Theoretically the unit could produce more at full engine rated output, but pump life will be shortened, possibly dramatically.

On the standard power unit, a diesel engine drives the single stage pump at a setting of 1800 rpm. The pump delivers 27 GPM at 1000 rpm and 67 GPM at the engine's maximum speed of 2500 rpm.

The Hi/Low power unit has a dual stage pump, which delivers 46 GPM at 1000 rpm and 117 GPM at the maximum 2500 rpm.



The unit is slightly overpowered for long service life. Exceeding the factory set pressures is not recommended.

Review the Deutz engine manual, Appendix A, for detailed instructions on startup, shut down and operation. The engine is controlled by the hydro-throttle, which opens the throttle as the load increases. The engine is protected from low oil pressure and high oil temperature by a Sentinel system. If the engine's oil temperature goes above 225°F or has an oil pressure of 0.50 psi or less, the Sentinel stops the fuel flow. An emergency shut off valve is shown in Figure 6. Press stop button on the valve to stop the engine in an emergency. A remote stop switch is available for the electric start engine only.

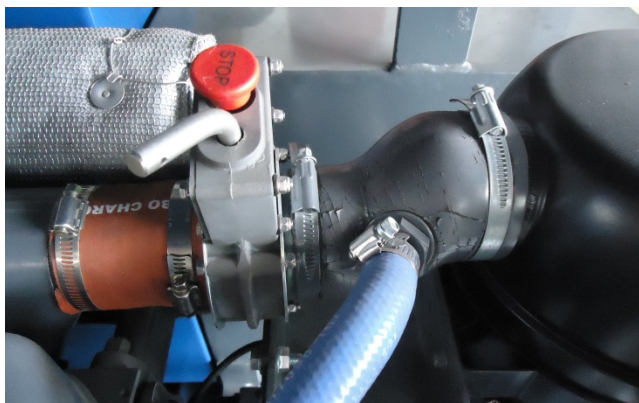


Figure 6



Open the valve by rotating the reset lever clockwise as far as possible before restarting the engine

- 1) Connect the battery (Figure 7) or air supply if disconnected (Figure 8).



Figure 7: Battery box

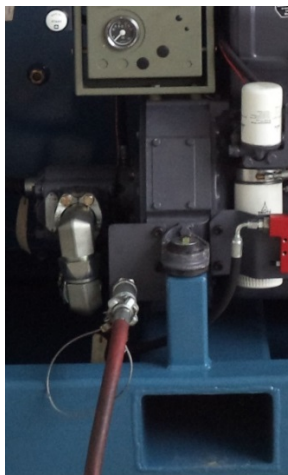


Figure 8: Air connection

- 2) Turn the key to the ON position and then the START position on the main enclosure or push the 'Engine Start' button for air start units.
- 3) To turn the unit off, turn the key to OFF (electric) or pull the throttle rod (air) to release the spring.

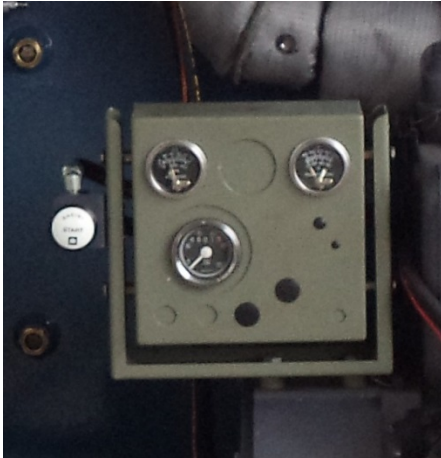


Figure 9: Air start control panel



Figure 10: Electric LOFA start control panel



If the power unit shuts down prematurely, check fuel tank for diesel. If the Sentinel system caused the shutdown, allow the engine to cool and check the oil level – add as needed. If this happens repeatedly, there is an abnormal condition which must be found and fixed before continuing operation

The standard unit's 'Start' position registers pressure (and generates heat in the hydraulic fluid) and the 'Run' position sends fluid out to the equipment.

The 'Start' position on the Hi/Low unit will allow the engine to warm and dump the fluid back into the tank. It also permits the system to operate at a lower flow for running tubing and a higher flow for casing. See lever example in Figure 11.



Figure 11

Hydraulic fluid cooling is provided on the return line with an oversized air to oil cooler (item 21 on Figure 16). The cooler is capable of removing nearly half the entire horsepower rating in heat, so hydraulic temperatures can be kept low for safety and for

system longevity with a reasonable flow of cooling air. On the standard unit, control the temperature by manually adjusting the speed of the oil cooler fan motor while observing the thermometer. The Hi/Low unit manifold automatically adjusts the cooler fan's speed. A needle valve can be added to the cooler fan for colder climates.

The suction line has a 149 micron filter in the hydraulic tank. Full filtration is equipped on the return line. The filter (item 3 on Figure 16) is mounted on the top of the tank and has a filter condition indicator mounted on the side of the filter housing. The condition indicator shows when the filter is operating properly, is bypassing (dirty filter), or is missing. Keeping the filter in good condition is strongly recommended, as dirt in the system will increase wear in the pump, valves and connected tools or other hydraulic tools.

Hoses and fittings have JIC swivel connections, SAE flange connections, or NPT connections. A shutoff valve (Figure 12) is on the tank so it can be drained and serviced.

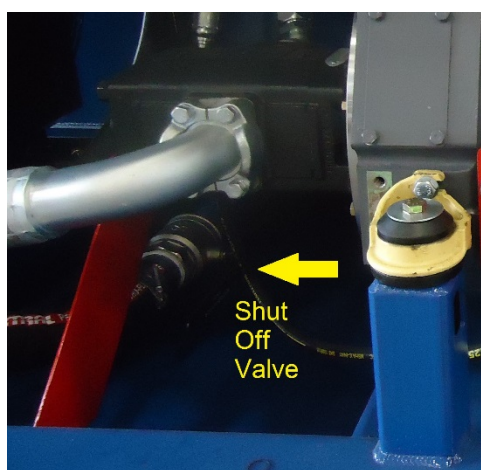


Figure 12

Be sure the equipment being operated is an 'open center' hydraulic circuit – meaning that in the neutral position the circuit has full flow from the inlet to the outlet. If not, a 'closed center' adapter must be installed.

ADJUSTMENTS

To adjust the relief valve, turn the adjustment screw clockwise (in) to raise the relief pressure and turn it counterclockwise to lower the relief pressure. The valve is set at 2500 psi. The relief valve, shown in Figure 13, requires a 5/32" Allen wrench (screw) and 9/16" wrench (locknut). The relief valve in the Hi/Low manifold, can be adjusted using an Allen wrench and is shown in Figure 15.



Adjustments should be made with the fluid at normal operating temperature of 80 to 130 degrees F

The relief valve setting can be determined by operating the unit without equipment connected to the quick disconnects, in 'Start', and observing the pressure reading on the panel gauge.



Do not operate the unit with equipment disconnected for over five (5) minutes. Keep temperature at or below 130 degree F

If installed, the oil cooler fan motor needle valve (shown in Figure 14) can be adjusted by rotating the needle clockwise (viewed from the top) to slow down and counterclockwise to speed up the fan. On Hi/Low units, the fan speed is controlled automatically by the manifold. A needle valve can be added to the fan for colder climates.

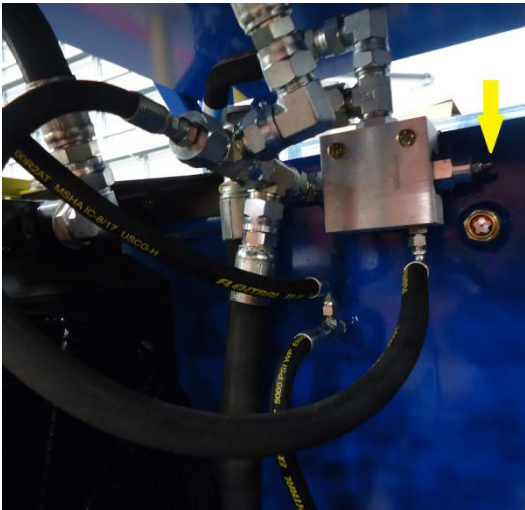


Figure 13: Without manifold

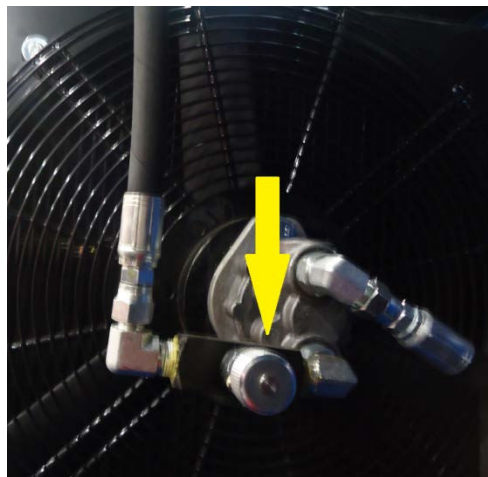


Figure 14: Oil cooler fan manual adjustment

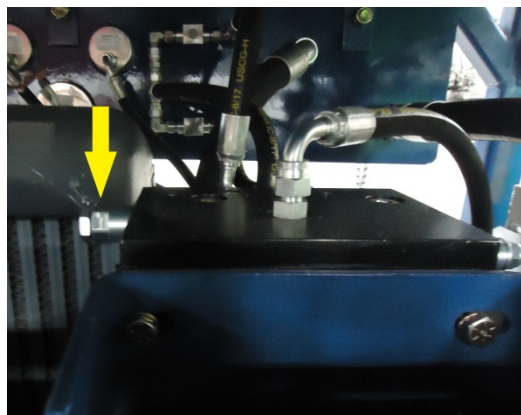


Figure 15: Relief valve on manifold on Hi/Low – view from tank side

To adjust hydro throttle (item 12 in Figure 16) see Appendix C.

DEPRESSURIZE AIR SYSTEM

When the air start power unit is disconnected from the supply air, remove air from unit by either using the pop-off valve (if supplied) or by pressing the air start button twice.

PREVENTIVE MAINTENANCE



This is a suggested PM schedule. The tool owner has the responsibility to adjust the program according to actual tool usage



Disconnect hydraulic lines and drain system's pressure before maintenance

Verify that the equipment to be operated is properly connected to the power unit as specified in the Hydraulic section on page 11. Cracks or the appearance of damage on the hydraulic hoses or electrical cabling can indicate the need for repair, even impending failure, and requires prompt attention. See Appendix A, Sections 5 and 6 for engine maintenance.

Daily – While in use

- Verify power unit is in a secure and safe location
- Inspect the hydraulic hoses for worn or scraped areas, bubbles, wrinkles or any other wear – if found, replace
- Verify power cables and hydraulic hoses are not a trip hazard and can't be pinched or cut
- Check for exposed wires and that electrical connections are secure
- Notice the hydraulic level using the sight gauges and ensure tank is filled to the proper level



Most items in the unit are lubricated by the hydraulic fluid and don't require other lubrication other than to ensure the fluid is clean

- Check the diesel tank has adequate fuel for the intended operation



Refuel safely with the engine OFF

- Verify cooling air can freely flow through the oil cooler fan and on standard units, the cooling fan is properly adjusted



Fluid temperature will increase 80°F in 20 minutes without air flow from the fan

- Ensure the shutoff valve to the pump inlet is fully open
- Once operating, check the return filter state



Run electric start power unit at least once every three (3) days so that the battery stays charged

Quarterly

- Replace filter element or earlier if the filter's indicator gauge shows a dirty element (before needle is in the red)
- Change the hydraulic fluid every three (3) to six (6) months – see recommended fluid on Table 14

TROUBLESHOOTING

Failure Mode	Possible Cause	Possible Solution
Pump excessively noisy	Pump inlet flow	Ensure that nothing in tank blocks tank outlet
		Verify suction shutoff valve is wide open
	Viscosity is too high	Change to a lower ISO VG grade
	Air	Pour fluid over suction side fitting - if noise stops, disassemble, retape and reassemble
	Loose or worn parts	Verify assembly is tight - replace worn out parts
Hydraulic system overheating	Cooling air - insufficient	Verify air flow is unobstructed
		Open needle valve fully
	Relief valve setting	Reset to a maximum of 2500 psi
	Fittings loose	Verify fittings fully tightened
	Fluid viscosity	Change fluid
	Excessive internal leakage	Check parts for wear - replace/repair
		Check for contamination
	Excess friction	Look at moving parts inside pump for proper fit
	Valves not operating properly	Check pressure and check flow with flow meter. Repair/replace valves
Excessive wear of moving parts	Fluid contaminated	Change fluid. Replace filter element. Clean breather.
	Engine/Motor to pump alignment	Verify fastener tightness. If OK, replace motor to pump housing and coupling
	Relief valve setting	Reset to a maximum of 2500 psi
	Air	Pour fluid over suction side fitting - if fluid disappears, disassemble, retape and reassemble
	Viscosity is too low	Change to a higher ISO VG grade
Flow rate (tool speed) is low	Pump inlet flow	Ensure the nothing blocks tank outlet
		Verify suction shutoff valve is wide open
	Pump	Inspect parts and replace as necessary
	Fittings	Confirm fittings are tight
	Viscosity	Change to a proper ISO VG grade
	Hoses	Use shorter or larger hoses
	Engine speed is low	Ensure hydro throttle is operational. RPM should be between 1800 and 2500
System pressure will not build up	Leak	Check hoses and fittings
	Relief valve setting	Adjust or replace

Table 16

Failure Mode	Possible Cause		Possible Solution
Hot or noisy operation	Fan		Remove interference with fan cover
			Tighten hold down bolts
	Misalignment		See engine vibrates below
	Insufficient oil		Lubricate per engine manual
	Deterioration of oil		Change
	Excess oil		Drain excess oil
	Engine/Motor loose		Check mounting bolts are tight
Engine will not start	Electric	Connections	Verify wiring connections/tighten
			Check voltage
		Battery dead	Recharge then find source of drain
	Air		Bleed fuel system
Engine stalls	Electric	Connections	Verify wiring connections/tighten
	Air		Bleed fuel system
	Both	Fuel filter	Dirty - replace
Engine runs and then slows/stops	Electric	Connections	Verify wiring connections/tighten
	Air		Bleed fuel system
	Sentinel system		Check oil level - if good - check oil pump operation
	Both	Overload	Adjust or replace hydraulic valves
		Fuel filter	Dirty - replace
Engine overheats	Overload		Adjust or replace hydraulic valves
	Air		Check for clogged air vents. Remove and clean
Engine vibrates	Loose pump mounting bolts		Tighten

Table 16 continued

For additional engine troubleshooting, see Appendix A, Section 7.

STORAGE AND TRANSPORTATION

- Unpainted surfaces should be coated with rust preventing agent
- Prevent excessive exposure to water and moisture
- Clean the tool after use - steam clean as needed; remove mud, debris and any other substances
- For long term storage, 1) depressurize the system and 2) flush hydraulic fluid. The fuel tank level indicates when the diesel contains water. 3) Drain tank as necessary

PARTS LIST

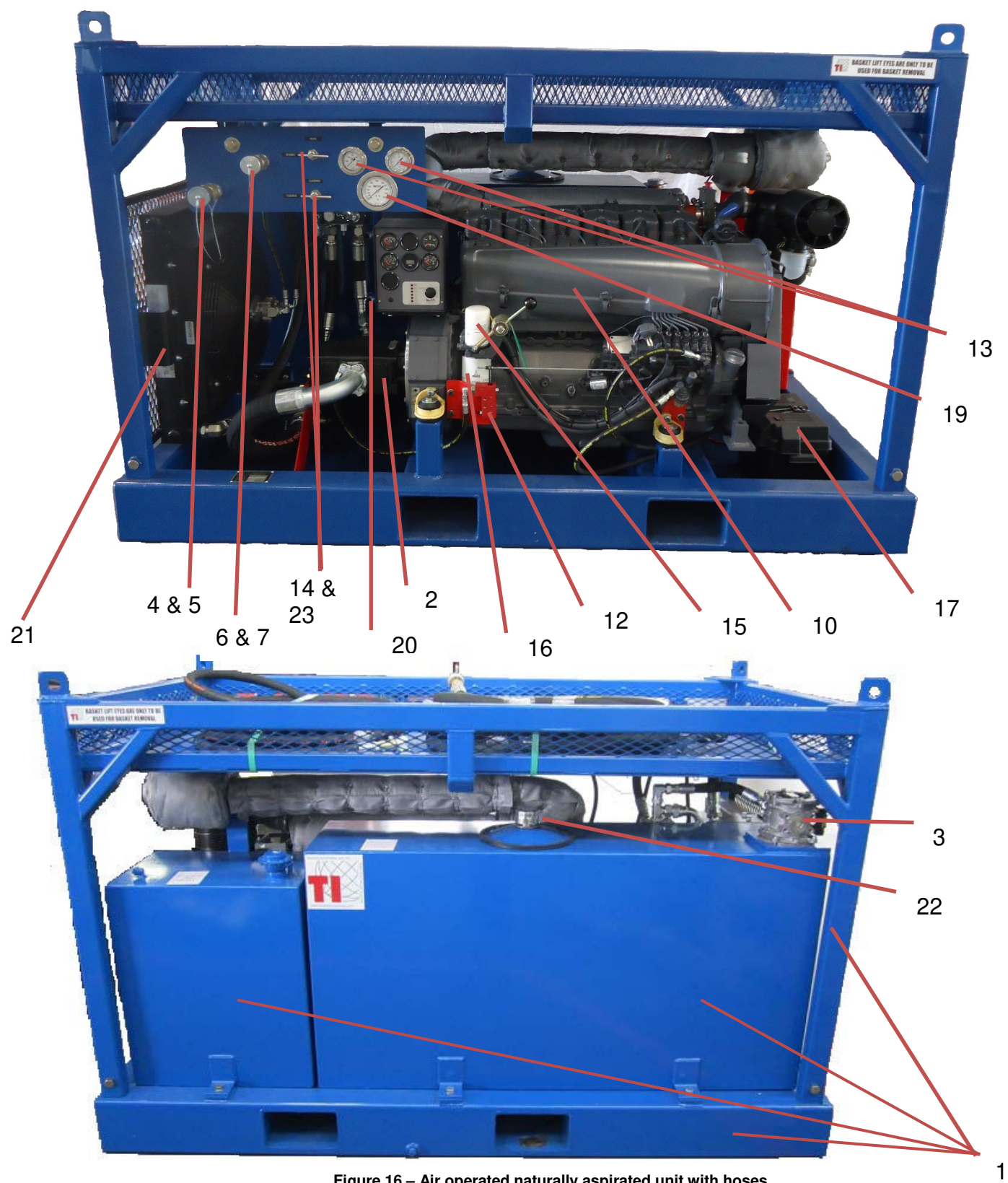


Figure 16 – Air operated naturally aspirated unit with hoses

ASSEMBLY P/N			TFBD914-AIR-V1-HL	TFBD914-ELEC-V1-HL
#	Component	Qty	P/N	P/N
1	SKID, BASKET, TANKS	1	TFB914-FKIT	
2	PUMP, HI/LO	1	060201	
3	RETURN FILTER - RFP	1	060017	
4	FEMALE QUICK DISCONNECT RETURN	1	030061	
5	RETURN CAP	1	030060	
6	FEMALE QUICK DISCONNECT PRESSURE	1	030062	
7	PRESSURE CAP	1	030063	
8	BALL VALVE, SHUT OFF*	1	060070	
10	DIESEL ENGINE	1	D914L06 - AIR START	D914L06 - ELECTRIC
11	SIGHT LEVEL GAUGE/TEMP	1	060066	
12	THROTTLE	1	080005	
13	GAUGE, PRESSURE	2	060012	
14	START/RUN BALL VALVE	2	060013	
15	FUEL FILTER	1	DEU1181917	
16	OIL FILTER	1	DEU1183574	
17	BATTERY	1	N/A	TFBD914-BATKIT
19	ANALOG PANEL THERMOMETER	1	060064	
20	SIGHT GAUGE PLUG	5	060065	
21	OIL COOLER	1	060075	
22	FILLER CAP/FILLER BREATHER	1	T17567-38	
23	HANDLE SS	2	060113	
24	MANIFOLD	1	060071	

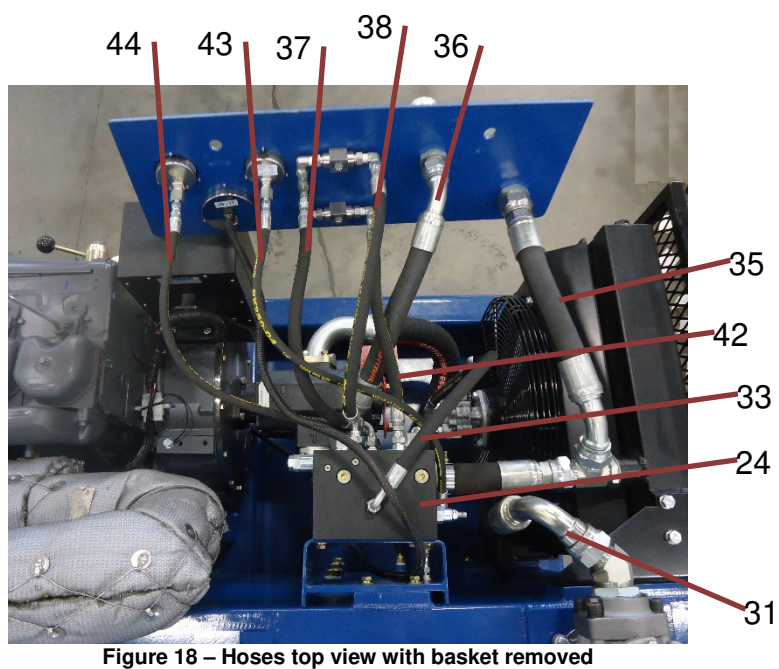
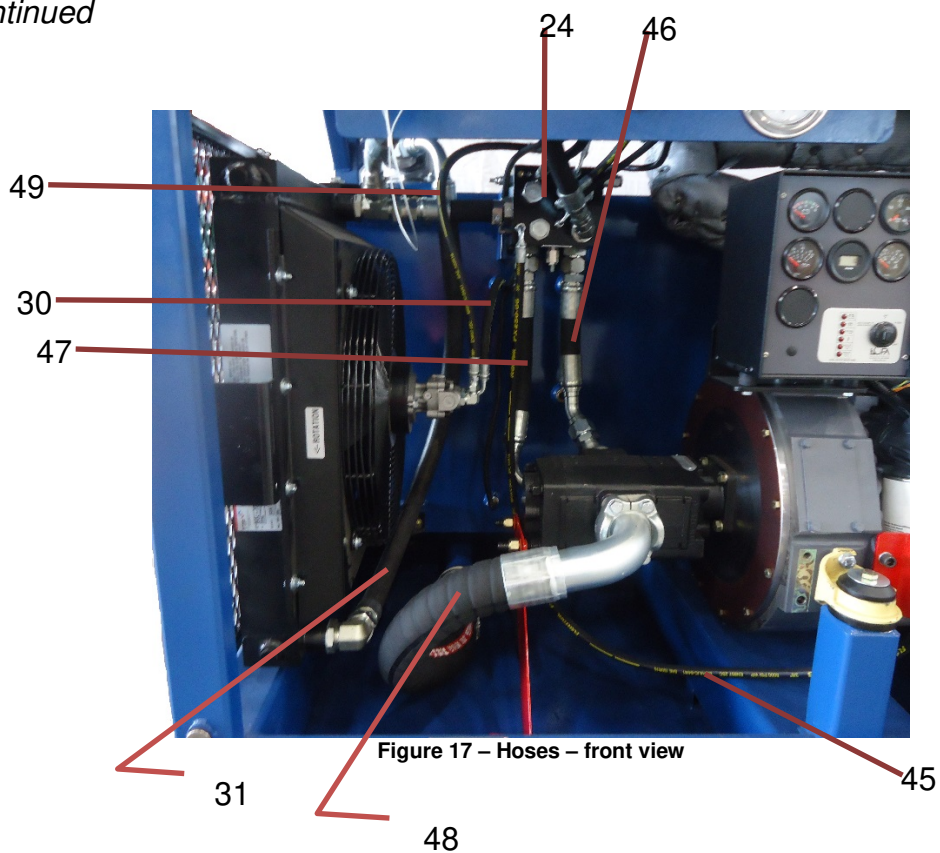
* Not shown

Table 17: Figure 16/17 BOM

ASSEMBLY P/N			TTCD914L06-AIR	TD914L06-ELEC
#	Component	Qty	P/N	P/N
10	DIESEL ENGINE	1	TTCD914L06-AIR-EKIT	D914L06 - ELECTRIC
17	BATTERY	1	N/A	TD914L06-5

Table 18: Turbo BOM* (not pictured)

*Not all items listed - excluded items are same as non turbo unit.



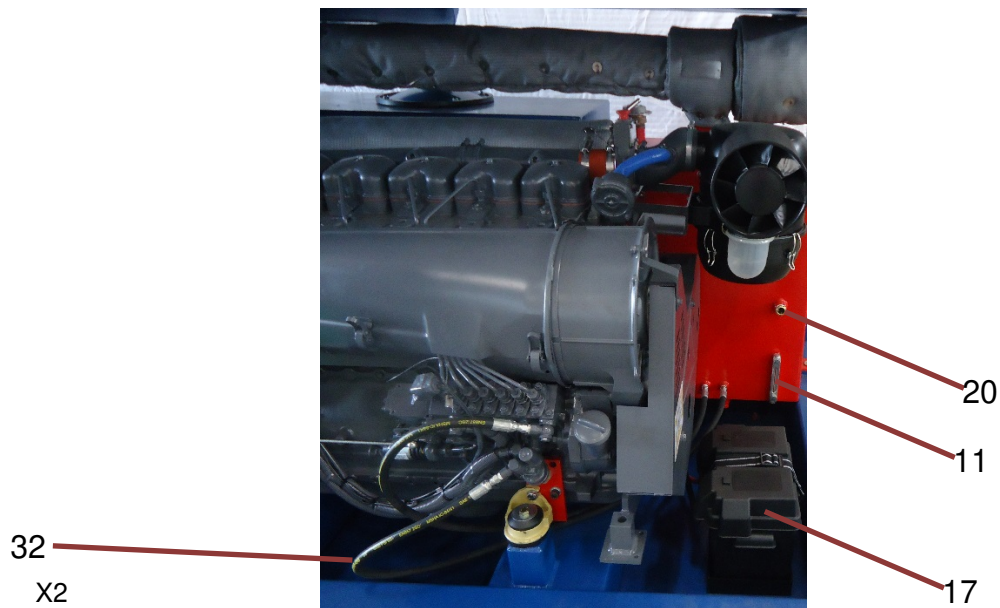


Figure 19 – Right Side

#	P/N	Description	Qty
30	050018	COOLER TO TANK	1
31	050027	RETURN LINE	1
32	050053	FUEL LINES	2
33	050061	MANIFOLD TO COOLER	1
35	050111	TO COOLER INLET	1
36	050113	RETURN 1" INLET TO MANIFOLD	1
37	050020	SWITCH TEE TO MANIFOLD	1
38	050112	START/RUN SWITCH TO MANIFOLD	1
42	050004	TUBING/CASING SWITCH TO MANIFOLD	1
43	050123	SYSTEM PRESSURE	1
44	050124	UNLOADING PRESSURE	1
45	050125	THROTTLE SETTING	1
46	050127	PUMP RELIEF	1
47	050126	PUMP UNLOADING	1
48	050128	PUMP RETURN	1
49	050129	MANIFOLD TO COOLER	1

Table 19 Hoses Figure 17, 18 and 19

SPARE PARTS LIST

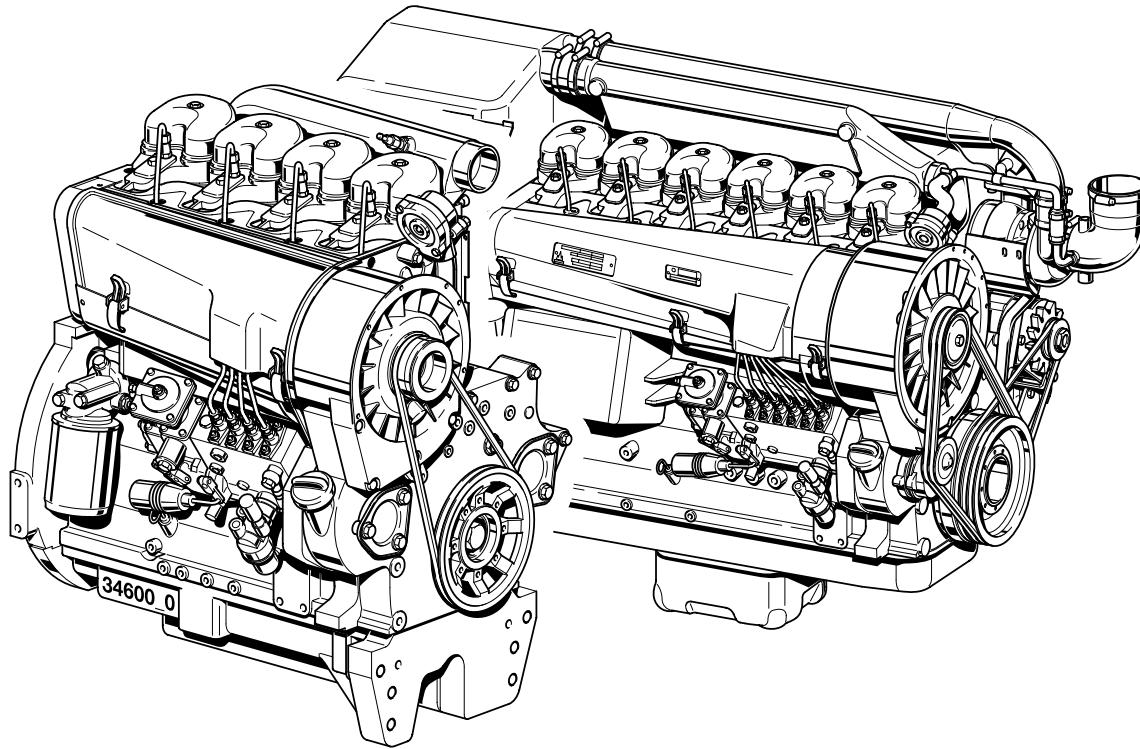
Component	Req	P/N
Element for Return Filter	2	060040
Fuel Filter	1	DEU1181917
Oil Filter	1	DEU1183574
Hose Kit	1	TFBD914-V1-HKIT
100' Return Hose (1")	1	050055
100' Hose (1-1/4")	1	050054
Suction Filter	1	060039
Pump (single)	1	060022
Pump (dual 40/40)	1	060201

Table 20

APPENDIX A

Operation Manual

914



APPENDIX A

Safety guidelines / Accident prevention



- Please read and observe the information given in this Operation Manual. This will enable you to avoid accidents, preserve the manufacturer's warranty and maintain the engine in peak operating condition.
- This engine has been built exclusively for the application specified in the scope of supply, as described by the equipment manufacturer and is to be used only for the intended purpose. Any use exceeding that scope is considered to be contrary to the intended purpose. The manufacturer will not assume responsibility for any damage resulting therefrom. The risks involved are to be borne solely by the user.
- Use in accordance with the intended purpose also implies compliance with the conditions laid down by the manufacturer for operation, maintenance and servicing. The engine should only be operated by personnel trained in its use and the hazards involved.
- The relevant accident prevention guidelines and other generally accepted safety and industrial hygiene regulations must be observed.
- When the engine is running, there is a risk of injury through:
 - turning/hot components
 - engines with positive ignition
 - ignition systems (high electrical voltage)You must avoid contact at all times!
- Unauthorized engine modifications will invalidate any liability claims against the manufacturer for resultant damage. Manipulations of the injection and regulating system may also influence the performance of the engine, and its emissions. Adherence to legislation on pollution cannot be guaranteed under such conditions.
- Do not change, convert or adjust the cooling air intake area to the blower. The manufacturer shall not be held responsible for any damage which results from such work.
- When carrying out maintenance/repair operations on the engine, the use of DEUTZ original parts is prescribed. These are specially designed for your engine and guarantee perfect operation. Non-compliance results in the expiry of the warranty!
- Maintenance and cleaning of the engine should only be carried out when the engine is switched off and has cooled down. You must ensure that the electrical systems have been switched off and the ignition key has been removed. Accident prevention guidelines concerning electrical systems (e.g. VDE-0100/-0101/-0104/-0105 Electrical protective measures against dangerous touch voltage) are to be observed. When cleaning with fluids, all electrical components are to be covered impermeably.

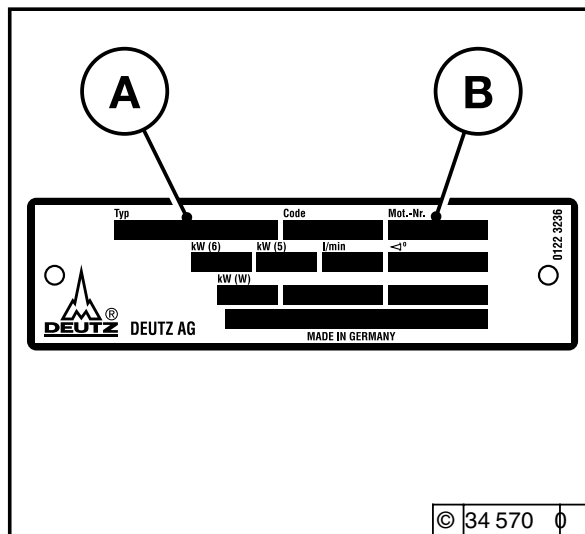
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Engine Description

2.1 Model

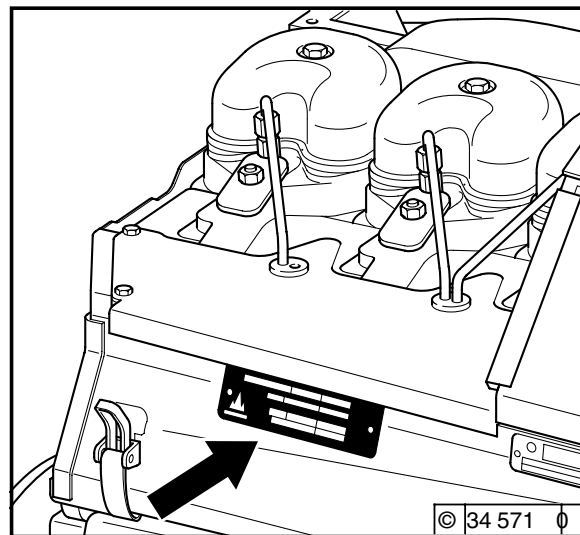
2

2.1.1 Rating Plate



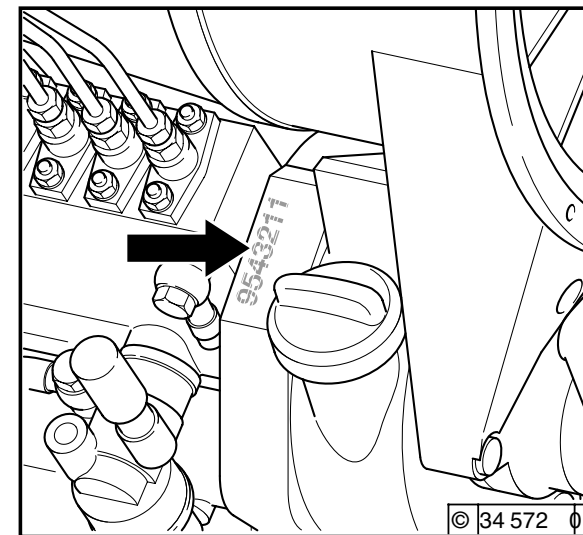
The model **A**, the engine serial number **B** and the performance data are stamped on the rating plate.
The model and engine serial number must be given when ordering parts.

2.1.2 Position of the Rating Plate



The rating plate **C** is attached to the crankcase. Depending on the model, a second rating plate may be affixed to the air duct hood.

2.1.3 Engine Serial Number

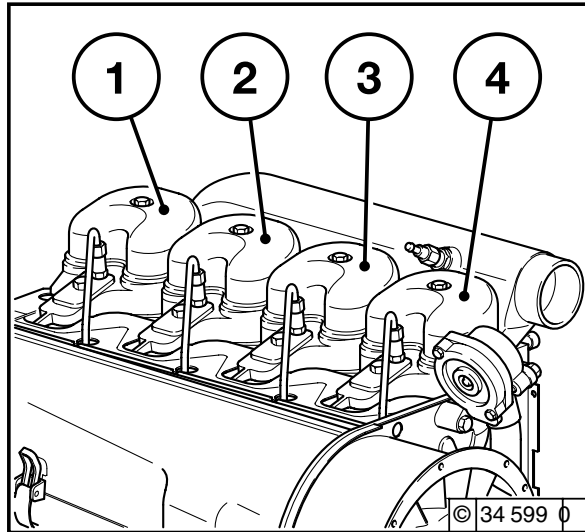


The engine serial number is stamped on the crankcase (**arrow**) as well as the rating plate.

2.1 Model

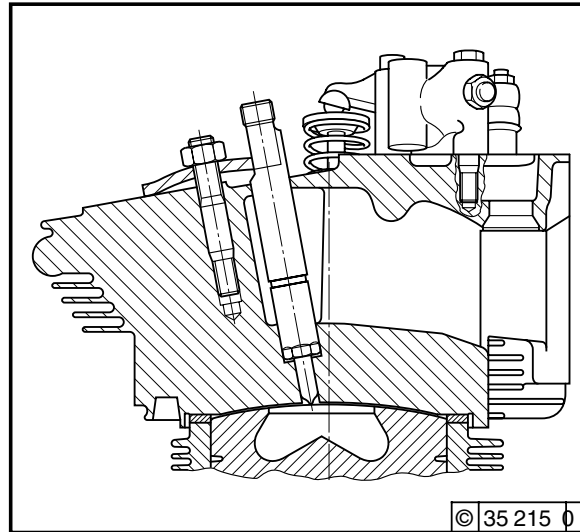
Engine Description

2.1.4 Cylinder numbering



Cylinders are numbered consecutively, beginning at the flywheel.

2.1.5 Direct injection B/FL 914



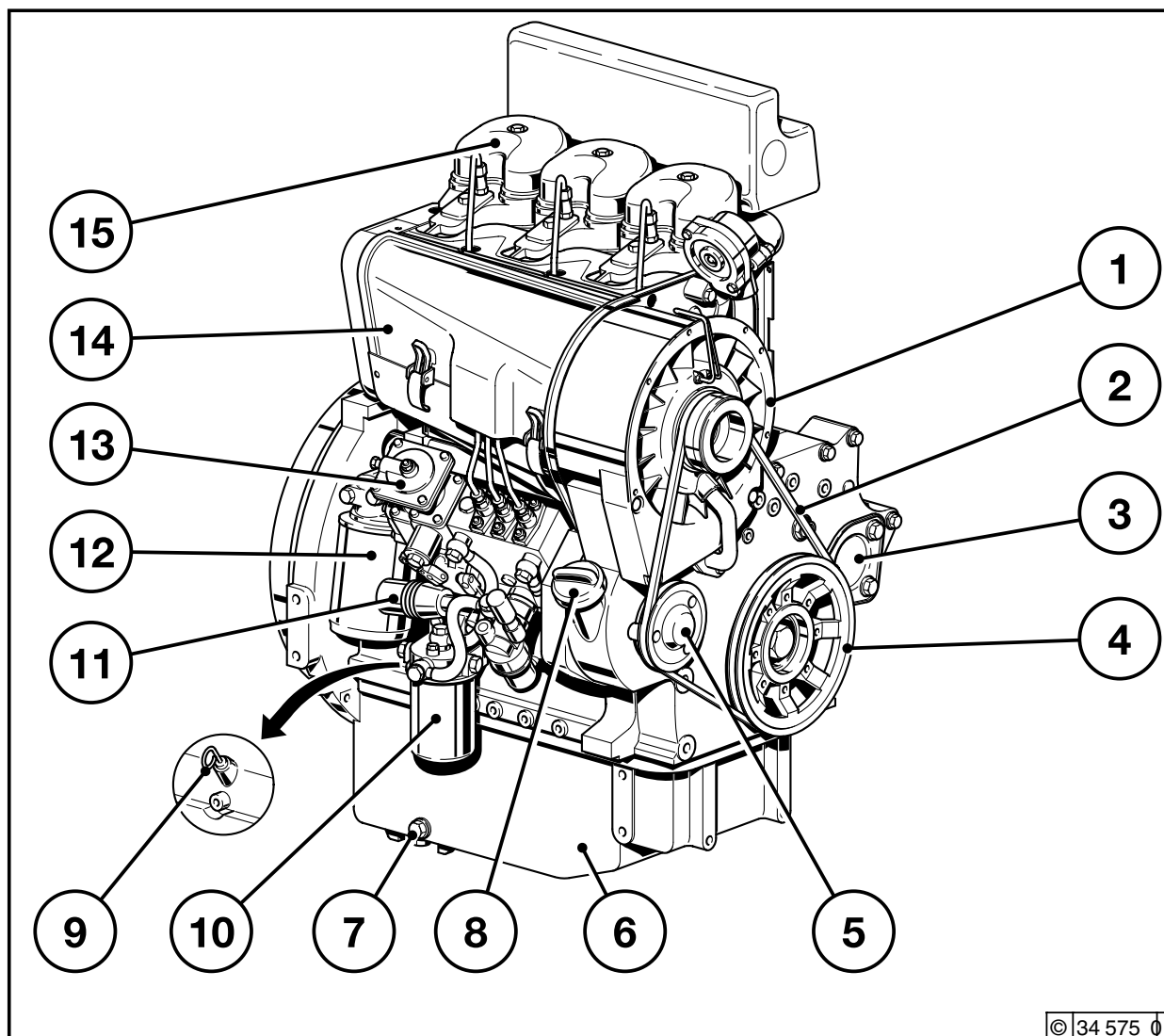
Engines with direct injection are used if high output is required.

Engine Description

2.2 Engine Illustrations

2

2.2.1 Operation side BF3L914



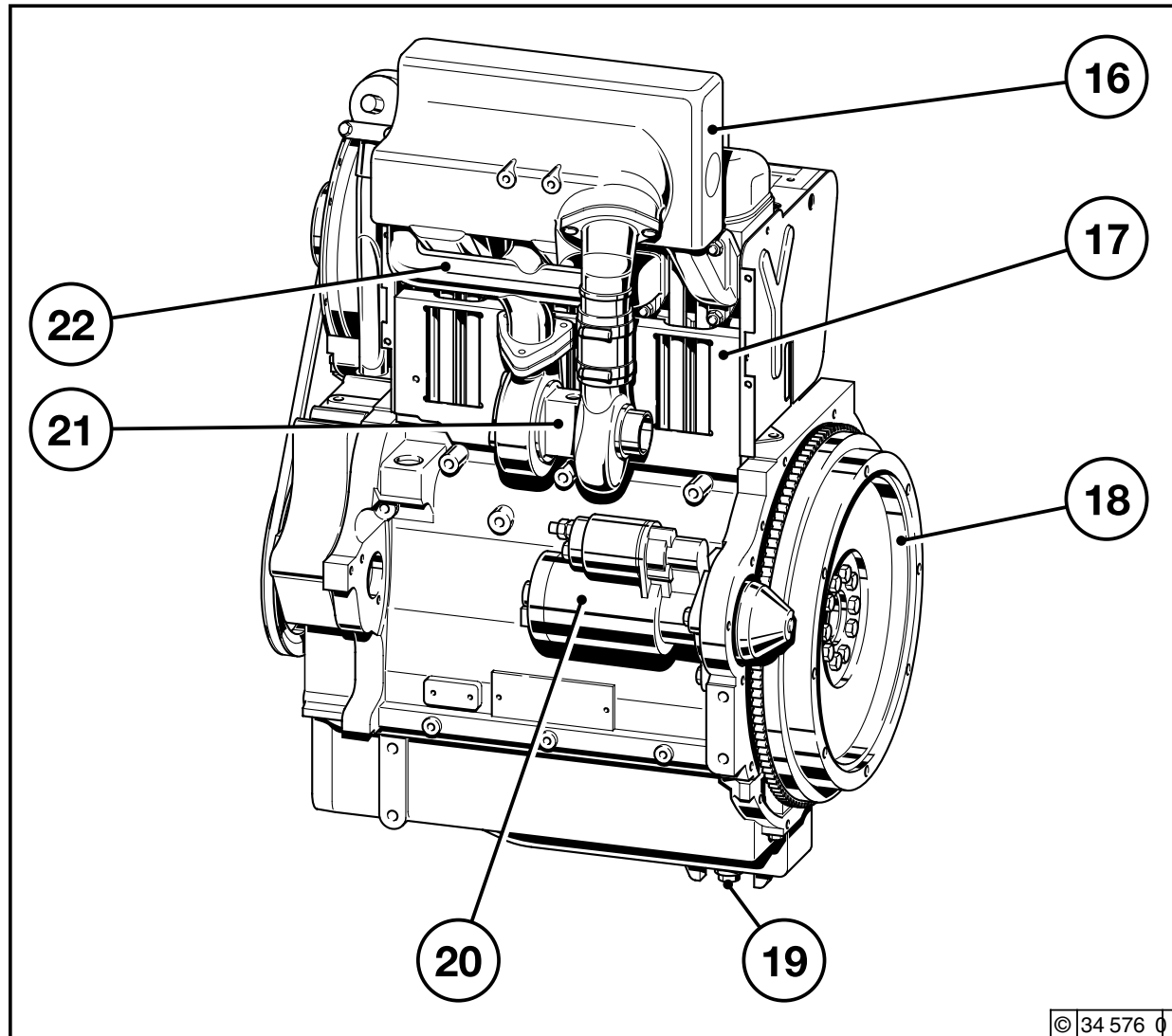
- 1 Cooling fan
- 2 V-Belts (fan)
- 3 Optional attachment of hydraulic pumps
- 4 V-belt washer
- 5 Tension roller
- 6 Oil pan
- 7 Oil drain screw
- 8 Oil filler neck
- 9 Oil dipstick
- 10 Fuel change filter
- 11 Solenoid (shut-off magnet)
- 12 Lube oil filter
- 13 Full-stop depending on charge air pressure
- 14 Air duct hood
- 15 Cylinder head cover

2.2 Engine Illustrations

Engine Description

2.2.2 Exhaust side
BF3L914

2



- 16 Air-intake line
- 17 Shielding plate
- 18 Flywheel
- 19 Oil drain screw
- 20 Starter
- 21 Exhaust turbocharger manifold

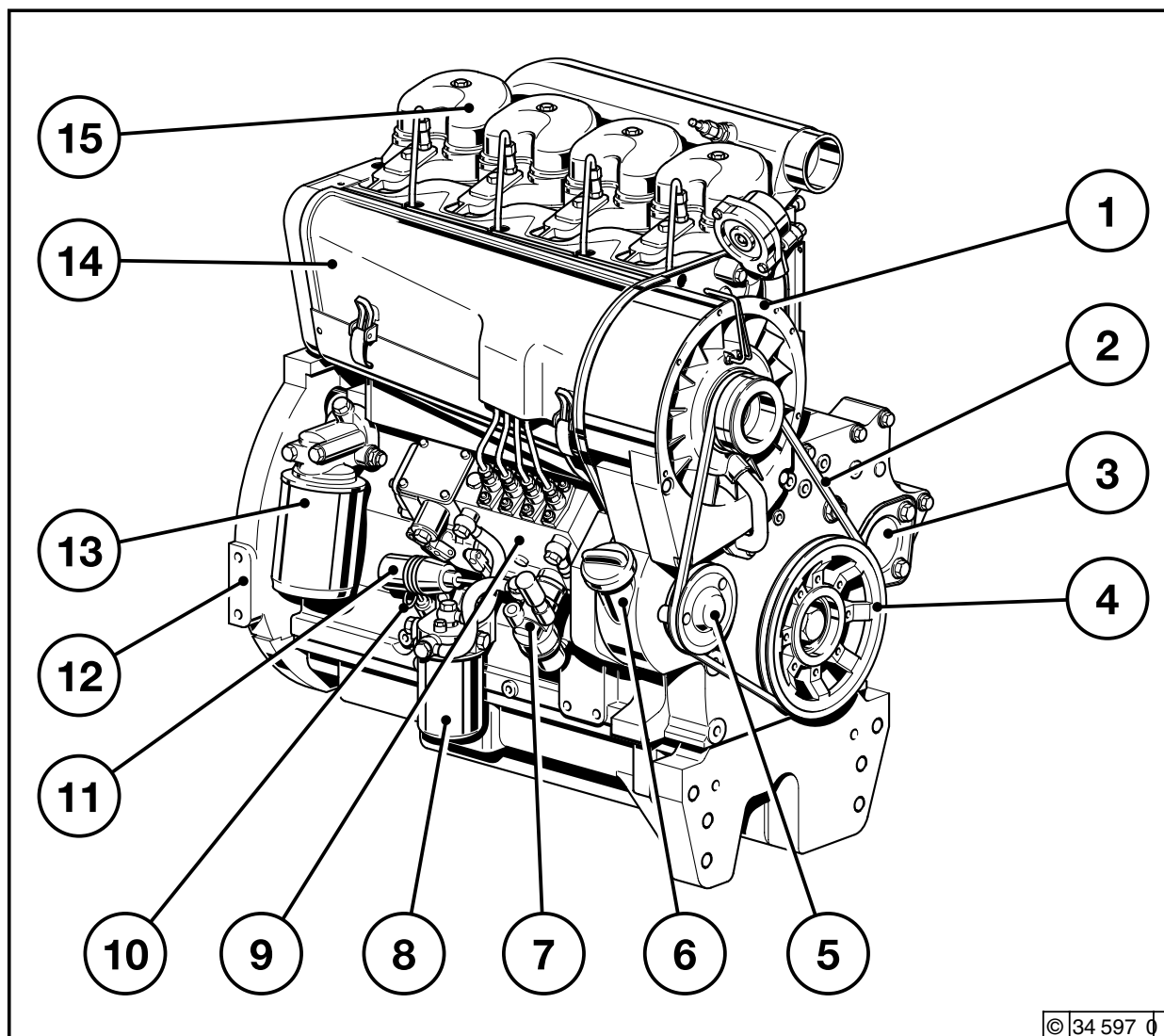
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Engine Description

2.2 Engine Illustrations

2

2.2.3 Operation side F4L 914



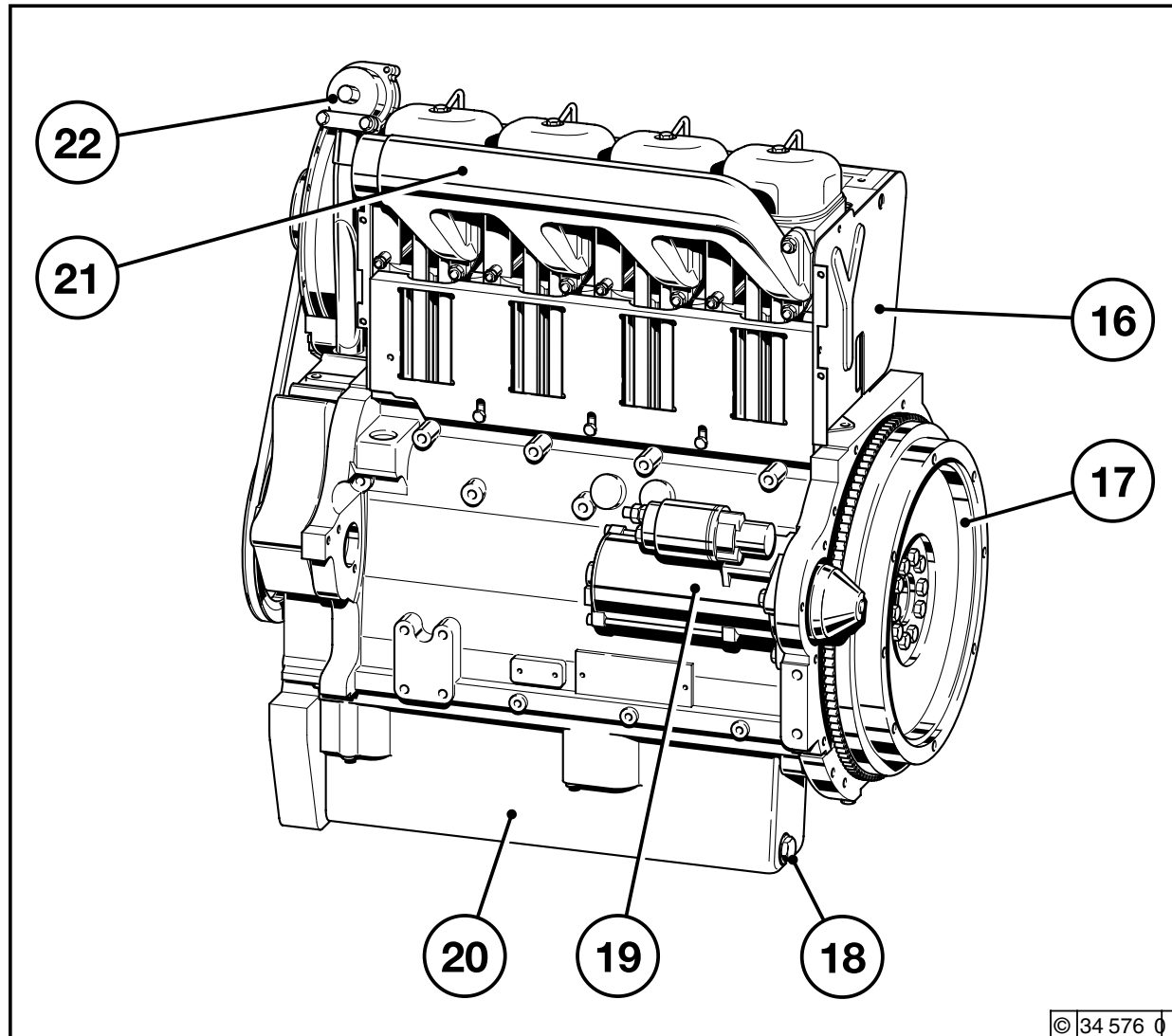
- 1 Cooling fan
- 2 V-Belts (fan)
- 3 Optional attachment of hydraulic pumps
- 4 V-belt washer
- 5 Tension roller
- 6 Oil filler neck
- 7 Fuel pump
- 8 Fuel change filter
- 9 Injection pump
- 10 Oil dipstick
- 11 Shut-off magnet
- 12 SAE housing
- 13 Lube oil filter
- 14 Air duct hood
- 15 Cylinder head cove

2.2 Engine Illustrations

Engine Description

2.2.4 Exhaust side
F4L 914

2



- 16 Date plate
- 17 Flywheel
- 18 Oil drain screw
- 19 Starter
- 20 Oil pan
- 21 Air-intake manifold
- 22 Crankcase ventilation

© 34 576 0

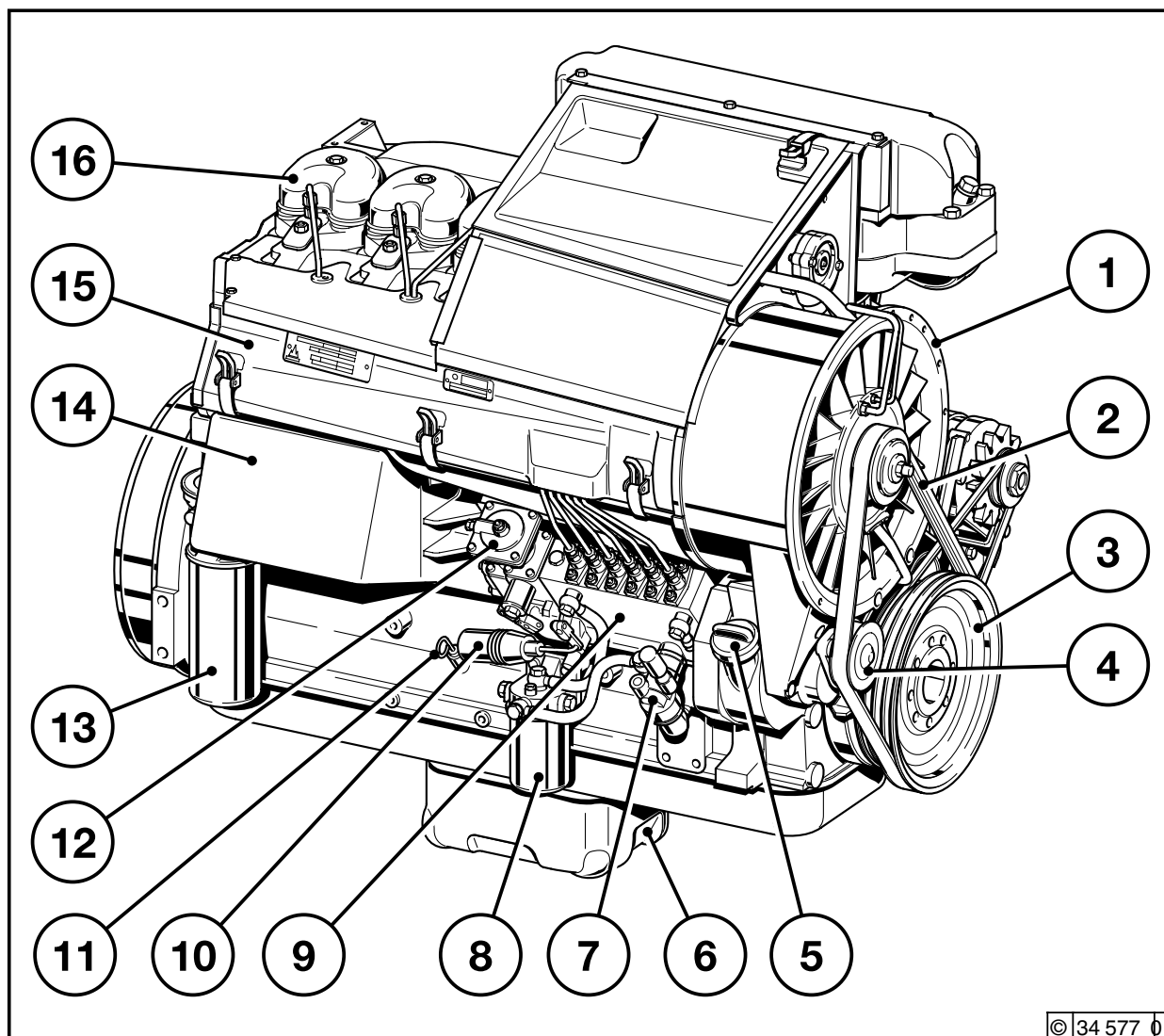
2.2 Engine Illustrations

Engine Description

2

2.2.5 Operation side

BF6L 914 C- intercooler over air-intake line



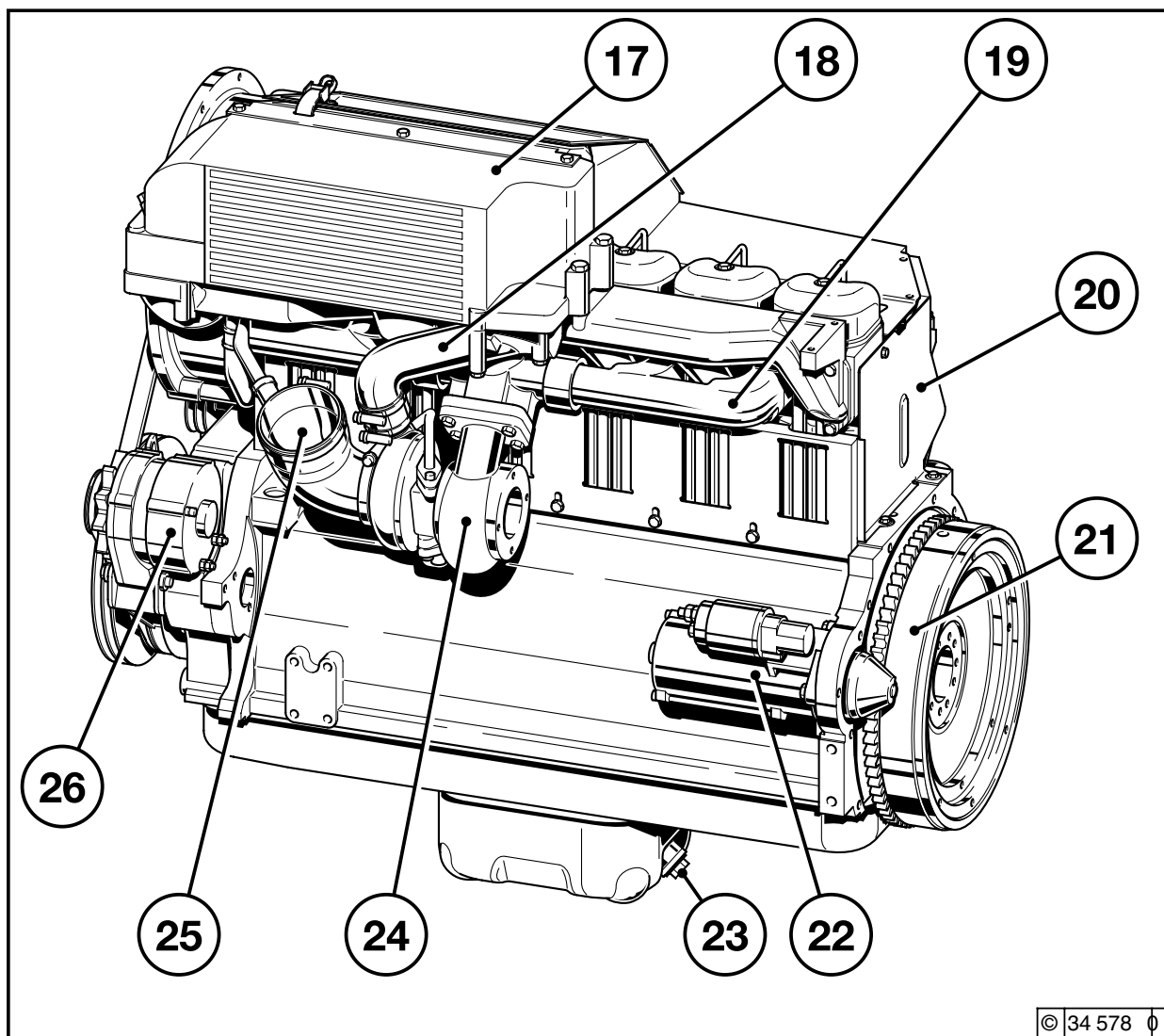
- 1 Cooling fan
- 2 V-Belts (fan)
- 3 V-belt pulley on crankshaft
- 4 Tension roller
- 5 Oil filler neck
- 6 Oil drain screw
- 7 Fuel pump with fuel precleaning
- 8 Fuel filter cartridge
- 9 Injection pump
- 10 Shut-off lifting magnet
- 11 Oil dipstick
- 12 LDA
- 13 Lube oil filter cartridge
- 14 Engine oil cooler
- 15 Air duct hood
- 16 Cylinder head cover

2.2 Engine Illustrations

Engine Description

2.2.6 Exhaust side

BF6L 914 C- intercooler over air-intake line



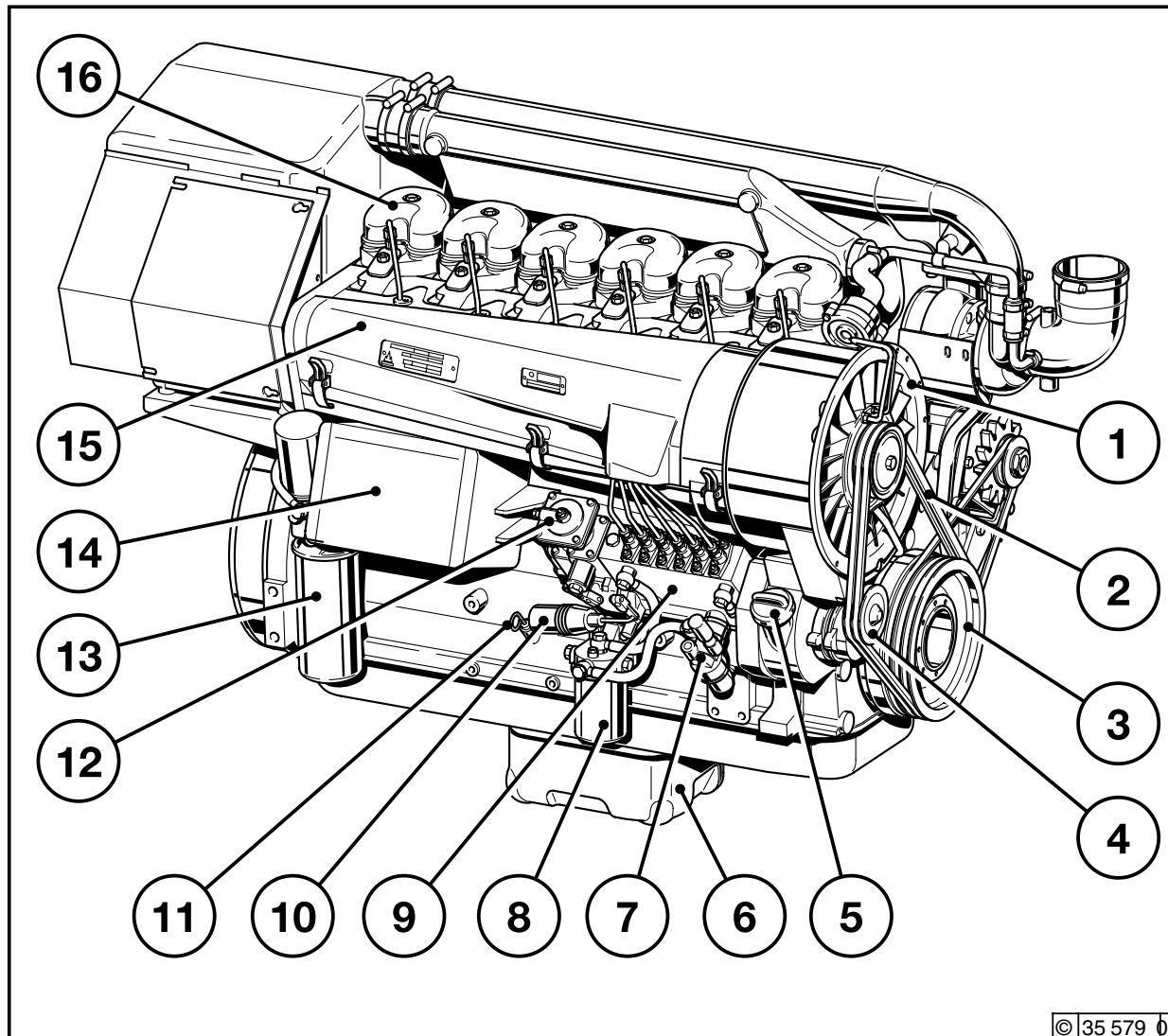
- 17 Intercooler
- 18 Air-intake line
- 19 Exhaust manifold line
- 20 Date plate
- 21 Flywheel
- 22 Starter
- 23 Oil drain screw
- 24 Turbocharger
- 25 Air-intake manifold to exhaust turbocharger
- 26 Alternator

Engine Description

2.2 Engine Illustrations

2

2.2.7 Operation side BF6L 914 C- intercooler over flywheel

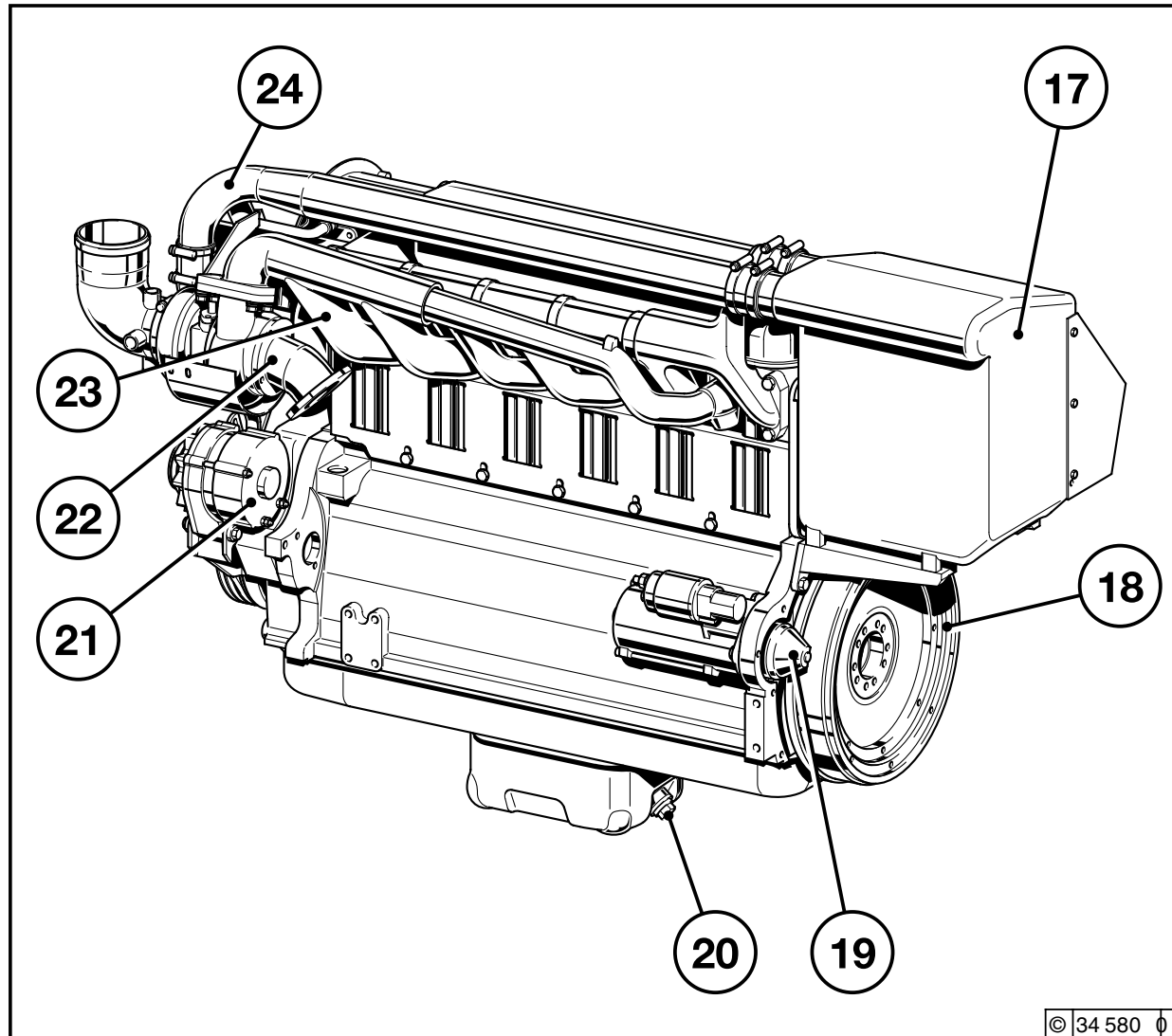


- 1 Cooling fan
- 2 V-Belts (fan)
- 3 V-belt pulley on crankshaft
- 4 Tension roller
- 5 Oil filler neck
- 6 Oil drain screw
- 7 Fuel pump with fuel precleaning
- 8 Fuel filter cartridge
- 9 Injection pump
- 10 Shut-off lifting magnet
- 11 Oil dipstick
- 12 LDA
- 13 Lube oil filter cartridge
- 14 Engine oil cooler
- 15 Air duct hood
- 16 Cylinder head cover

2.2 Engine Illustrations

Engine Description

2.2.8 Exhaust side BF6L 914 - intercooler over flywheel

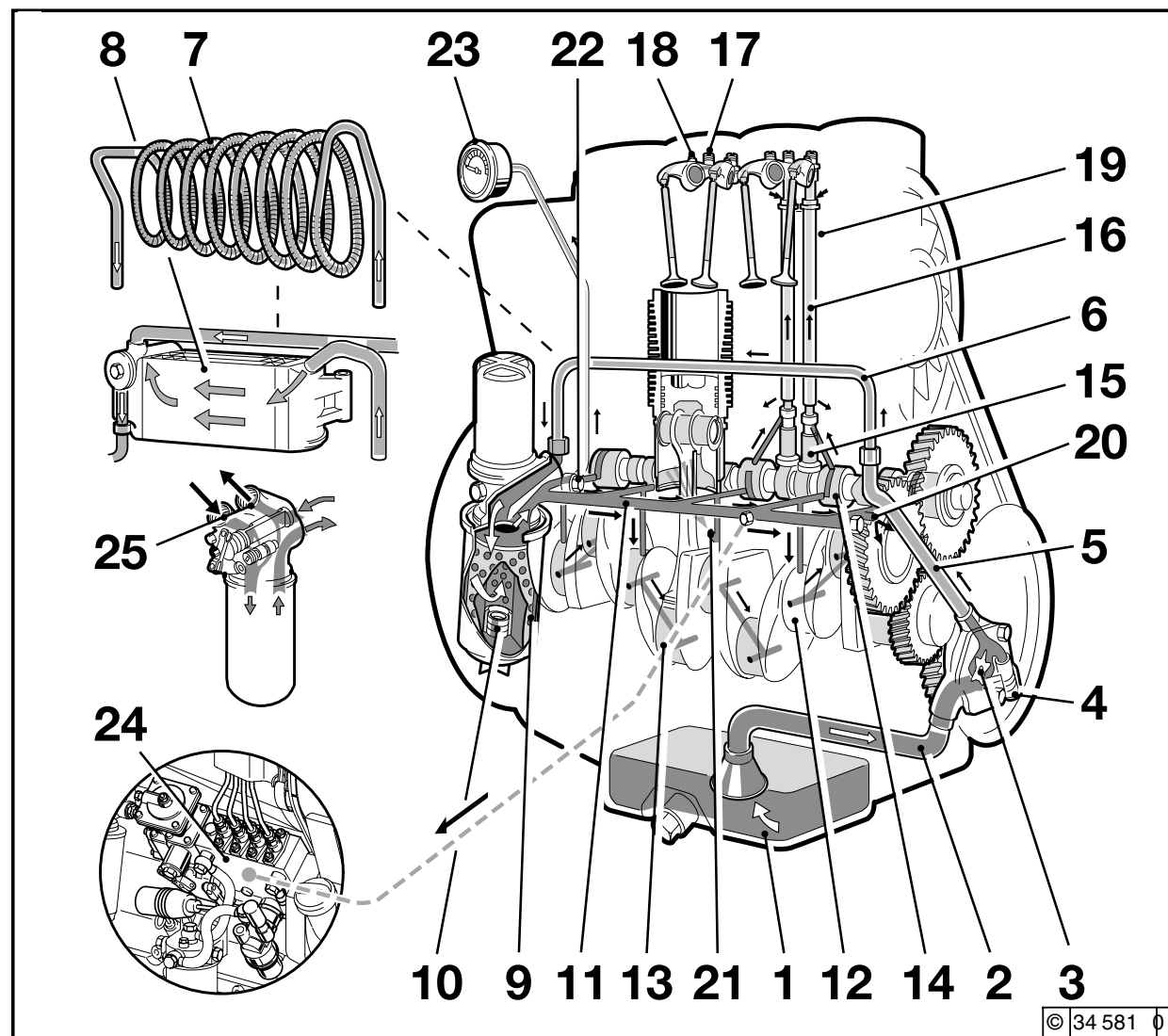


Engine Description

2.3 Lube Oil Circuit Schematic

2

2.3.1 Lube Oil Circuit Schematic FL 914



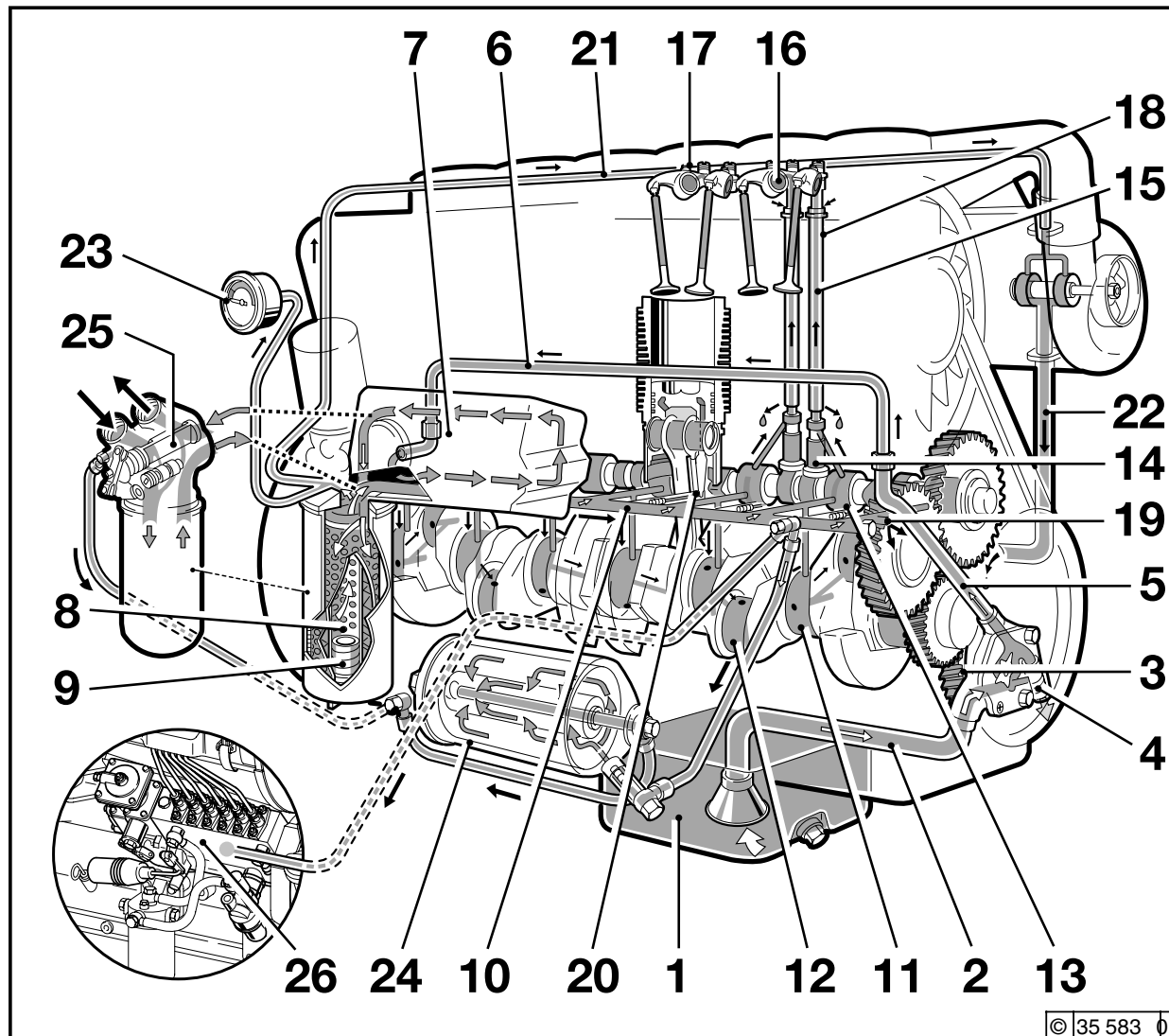
- 1 Oil pan
- 2 Intake manifold
- 3 Oil pump
- 4 Oil pressure regulating valve
- 5 Pressure oil line
- 6 Short-circuit line or alternative
- 7 Ribbed tube coil or alternative
- 8 Block oil cooler
- 9 Lube oil filter
- 10 Safety valve
- 11 Main oil channel
- 12 Crankshaft bearing
- 13 Con-rod bearing
- 14 Camshaft bearing
- 15 Tappet
- 16 Pushrod (hollow, for oil intake to lubricate rocker arm)
- 17 Rocker arm bearings
- 18 Rocker arm lubrication
- 19 Pushrod protective tube
- 20 Throttle bore (to lubricate cogwheels)
- 21 Spray nozzle for piston cooling
- 22 Connection for oil pressure gauge
- 23 Oil pressure gauge
- 24 Injection pump connected to lube oil circuit schematic
- 25 Connection option for oil heater **

** here the filter carrier must be exchanged.
Please contact DEUTZ Service when changing-over.

2.3 Lube Oil Circuit Schematic

Engine Description

2.3.2 Lube Oil Circuit Schematic BFL 914



- 1 Oil pan
- 2 Intake line
- 3 Oil pump
- 4 Oil pressure regulating valve
- 5 Pressure oil line
- 6 Connection line to oil cooler
- 7 Block oil cooler
- 8 Lube oil filter
- 9 Safety valve
- 10 Main oil channel
- 11 Crankshaft bearing
- 12 Con-rod bearing
- 13 Camshaft bearing
- 14 Tappet (with impulse lubrication of rocker arm)
- 15 Pushrod (hollow, for oil intake to lubricate rocker arm)
- 16 Rocker arm bearings
- 17 Rocker arm lubrication
- 18 Pushrod protective tube (oil return from the cylinder head to crankcase)
- 19 Throttle bore (to lubricate cogwheels)
- 20 Spray nozzle for piston cooling
- 21 Oil line to lubricate turbocharger
- 22 Oil return line from exhaust turbocharger to crankcase
- 23 Oil pressure gauge
- 24 Bypass lube oil fine filter
- 25 Connection option for oil heater **
- 26 Injection pump connected to lube oil circuit schematic

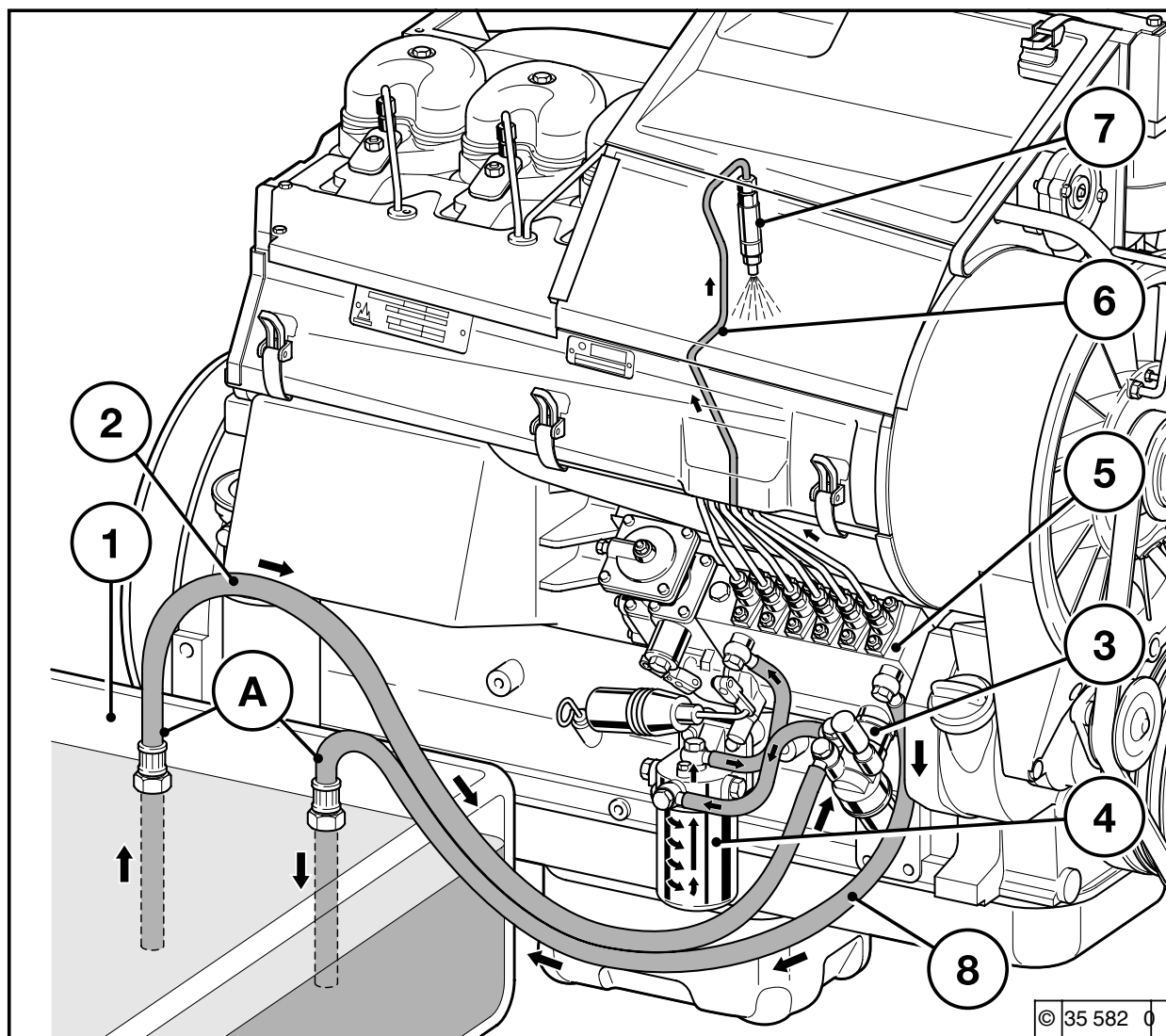
** here the filter carrier must be exchanged. Please contact DEUTZ Service when changing-over.

Engine Description

2.4 Fuel System Schematic

2

2.4.1 Fuel System



- 1 Fuel tank
- 2 Fuel line from tank to fuel pump
- 3 Fuel pump
- 4 Fuel change filter
- 5 Injection pump
- 6 Injection line
- 7 Injection valve
- 8 Fuel overflow pipe

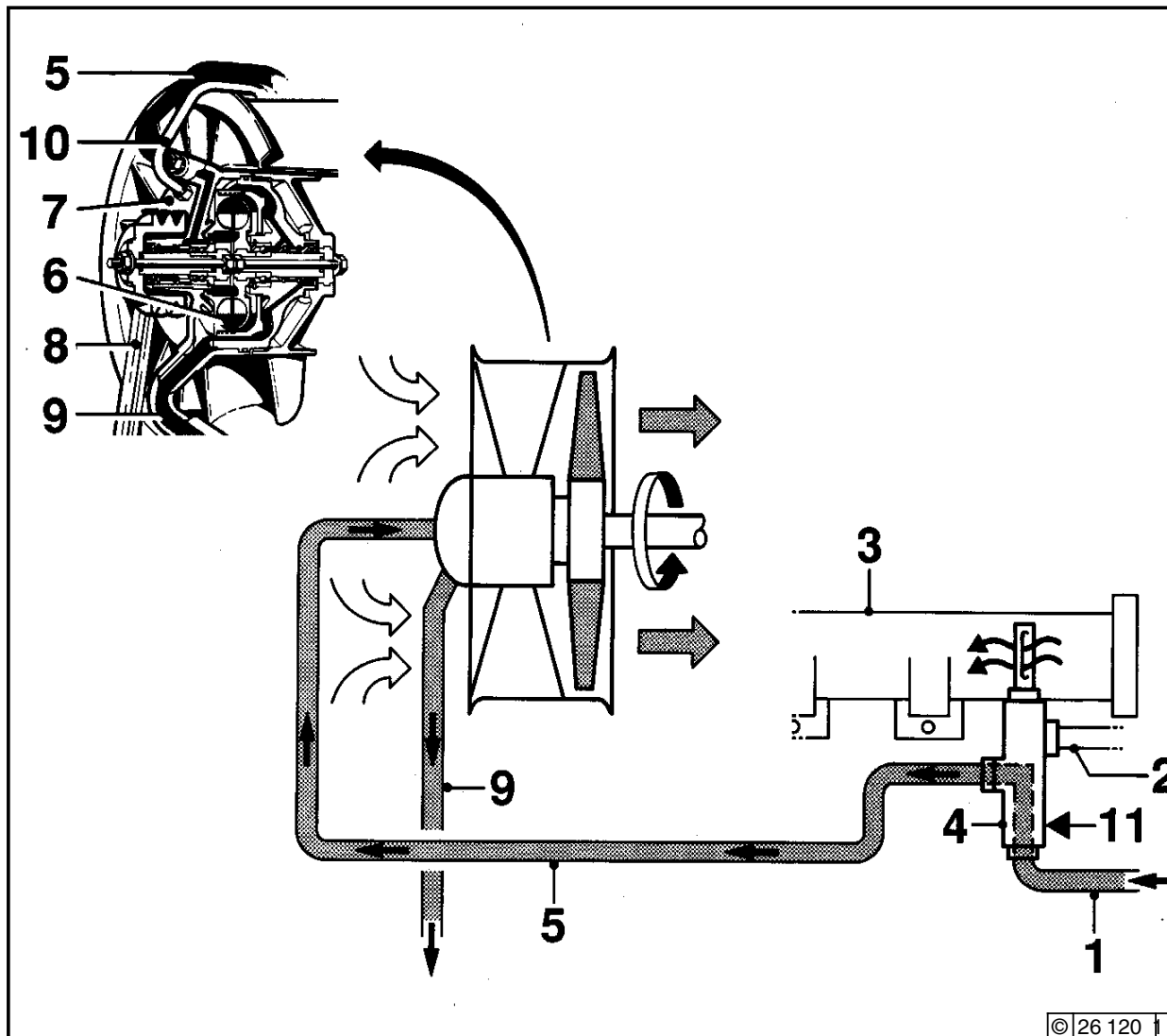
A Distance: must be routed as far away from each other as possible

2.5 Engine cooling

Engine Description

2.5.1 Amount of cool air regulated by exhaust thermostat

2



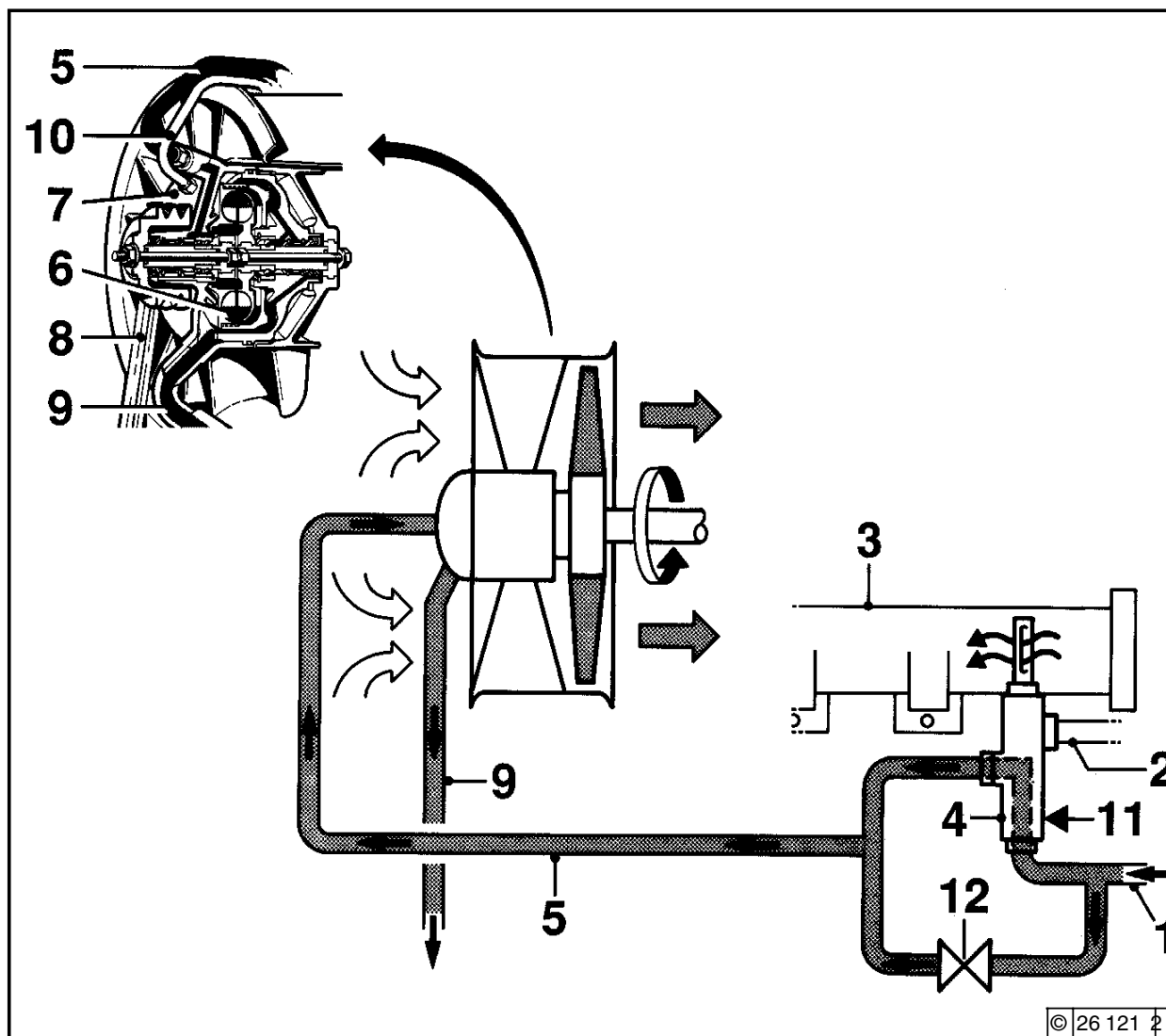
- 1 Pressure oil line from engine to exhaust thermostat
- 2 Air line to exhaust thermostat
- 3 Exhaust manifold line
- 4 Exhaust thermostat
- 5 Control line to hydraulic coupling
- 6 Hydraulic coupling
- 7 Cooling fan
- 8 Cooling fan drive
- 9 Oil return line to crankcase
- 10 Ventilation line
- 11 Adjusting screw with special seal ring

Engine Description

2.5 Engine cooling

2

2.5.2 Amount of cool air regulated by exhaust thermostat and solenoid valve



- 1 Pressure oil line from engine to exhaust thermostat
- 2 Air line to exhaust thermostat
- 3 Exhaust manifold line
- 4 Exhaust thermostat
- 5 Control line to hydraulic coupling
- 6 Hydraulic coupling
- 7 Cooling fan
- 8 Cooling fan drive
- 9 Oil return line to crankcase
- 10 Ventilation line
- 11 Adjusting screw with special seal ring
- 12 Solenoid valve

3.1 Commissioning

3.2 Starting

3.3 Monitoring Operation

3.4 Shutting off

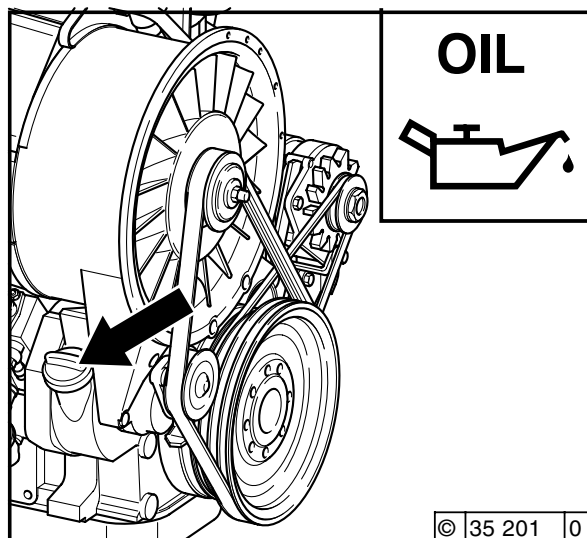
3.5 Operating Conditions

Engine Operation

3.1 Commissioning

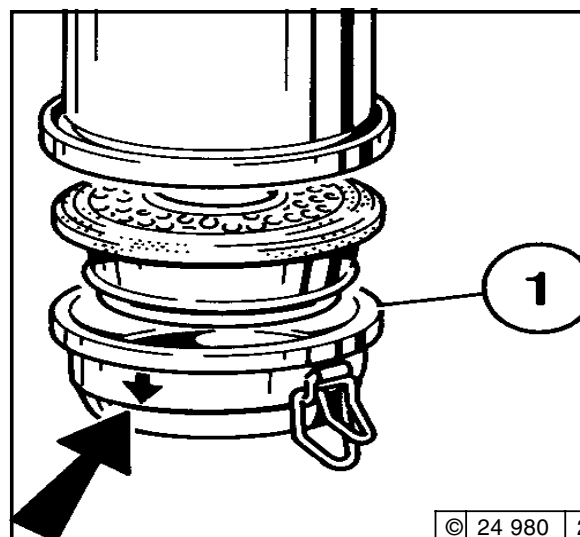
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3.1.1 Pour in Engine Oil



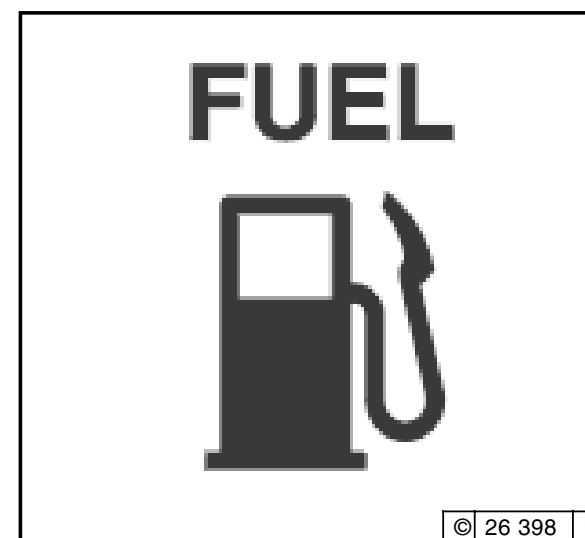
As a rule, engines are delivered without oil. Pour lube oil into the oil filler neck (arrow). For oil grade and viscosity, see 4.1.

3.1.2 Oil Bath Air Filter with Engine Oil



Fill oil cup 1 of the oil bath air cleaner with oil up to the arrow. For oil grade and viscosity, see 4.1.

3.1.3 Pour in Fuel



Use only commercial-grade diesel fuel. For fuel grade, see 4.2. Use summer or winter-grade fuel, depending on the ambient temperature.



Do not fill the precleaner dust collector (if fitted) with oil.



Never fill the tank while the engine is running. Ensure cleanliness! Do not spill fuel!

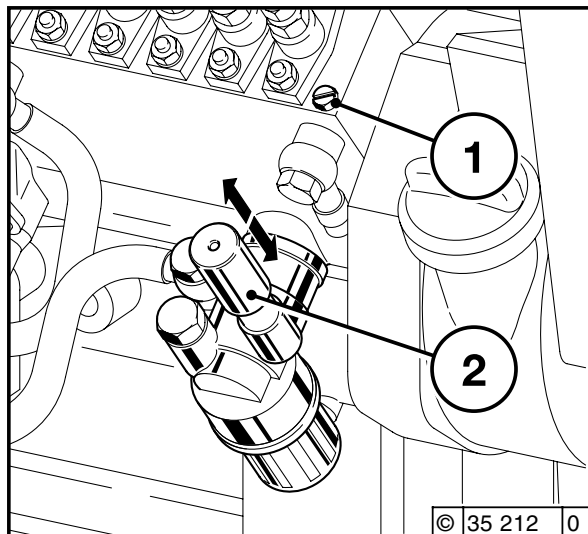
3.1 Commissioning

Engine Operation

3.1.4 Bleed

Model:

“Motorpal” model



- Position collecting tank below the injection pump.
- Unscrew ventilation valve 1 with screwdriver.
- Move hand hump 2 in the direction of the arrow until bubble-free fuel escapes from the ventilation valve 1.
- Tighten ventilation valve 1, still pumping.
- Remove collecting tank and dispose of the fuel in an environmentally-friendly manner.

Engine Operation

3.1 Commissioning

3

3.1.5 Other Preparations

- Checking battery and cable connectors see 6.7.1
- Transport hooks
Remove if fitted (see 6.7.3)
- Trial run
After the engine has been prepared, let it run for about 10 minutes without load.

During and after trial run
– Check the engine for leaks.

After the engine has been turned off
– Check the oil level, see 6.1.2
If necessary, top up oil, see 3.1.1
– Retension V-belts, see 6.5.

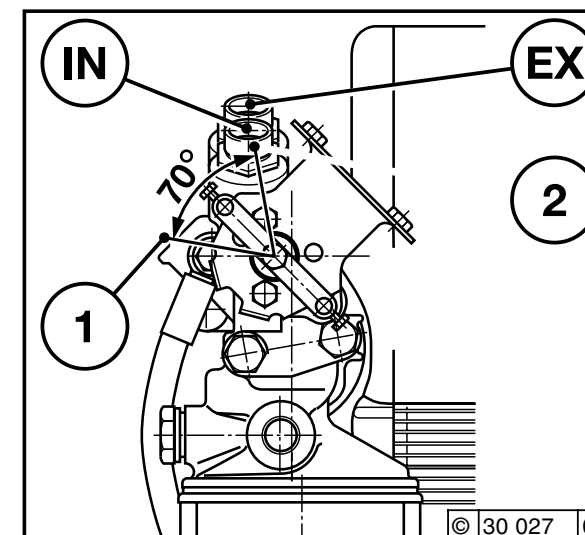
- Breaking in
During the break-in phase, about 200 operating hours, check the oil level twice a day. After the engine is broken in, checking once a day will be sufficient.

3.1.6 Additional maintenance work

After 50-150 operating hours, the following maintenance work is to be carried out:

- Change lube oil, see 6.1.2
- Change oil filter cartridge, see 6.1.3
- Change fuel filter cartridge, see 6.2.1
- Check V-belts and retension as necessary, see 6.5.
- Check valve clearance (adjust if necessary) see 6.6.1
- Check the engine for leaks
- Check engine mounts (retighten if necessary) see 9.2.

3.1.7 Change-over switch for oil heater



Position of change-over switch for oil filter consoles with an oil heater connected:
Pos. 1: open
Pos. 2: closed



For engines without an oil heater, the change-over switch should always be fixed to Pos. 2: closed.

Engine Operation

3.2 Starting

3

3.2.1 Electric Starting



Before starting, make sure that nobody is standing in the immediate vicinity of the engine or driven machine.

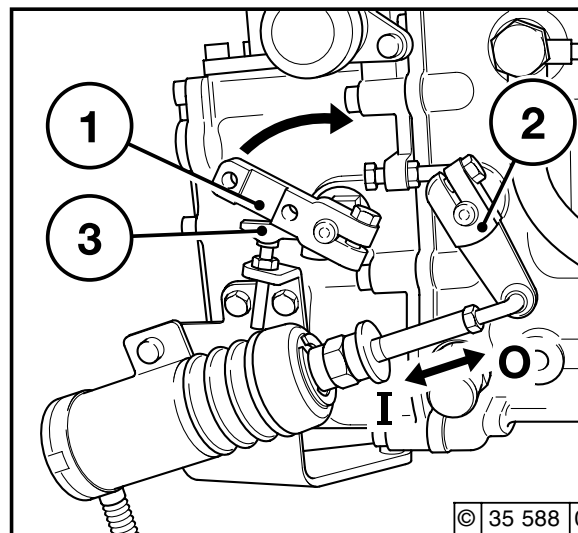
After repair work:

Check that all guards have been replaced and that all tools have been removed from the engine.

When starting with glow plugs, do not use any other starter substance (e.g. injection with start pilot). Risk of accident!

Caution:

If the speed regulator has been removed, the engine must not be tested under any circumstances: disconnect the battery!

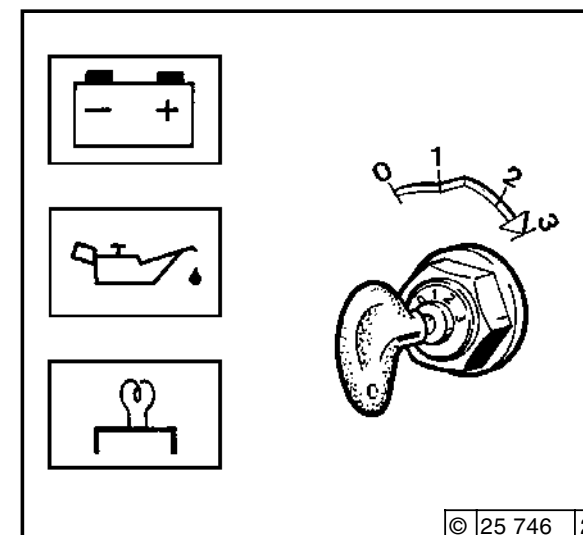


- Where possible, disengage the clutch to separate the engine from any driven parts.
- Move speed control lever 1 into idle position.
- Move cut-out handle 2 in direction of "I" and start.
- Regarding electric starting with a solenoid, the cut-out handle 2 is pulled in direction "I" and held when current is flowing. The charge pilot light and the oil pressure pilot light go out.

Do not actuate the starter for more than 20 seconds. If the engine does not catch, wait a minute then try again.

If the engine does not catch after two attempts, refer to the Diagnosis Chart (see 7.1).

without cold start assistance



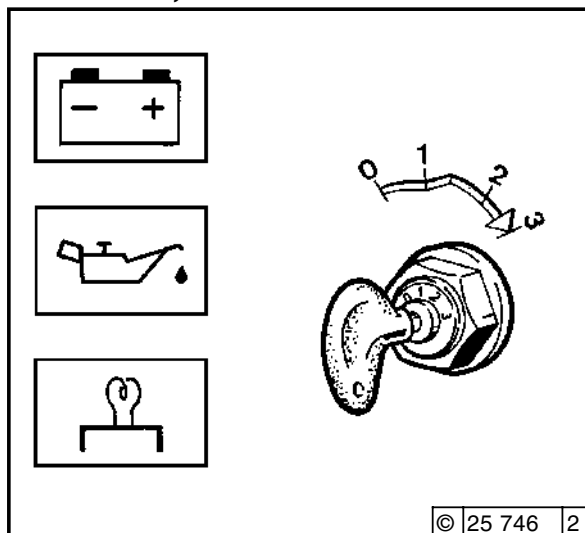
- Insert key
 - Position 0 = no operating voltage
- Turn key clockwise
 - Position 1 = operating voltage
 - Pilot lights illuminate
- Push key in and turn further clockwise against spring pressure.
 - Position 2 = no function
 - Position 3 = start
- Release key as soon as engine fires
 - The pilot lights will go out.

3.2 Starting

Engine Operation

with cold start assistance/glow lamps

FR 60 = 9,5 and 19 Volt

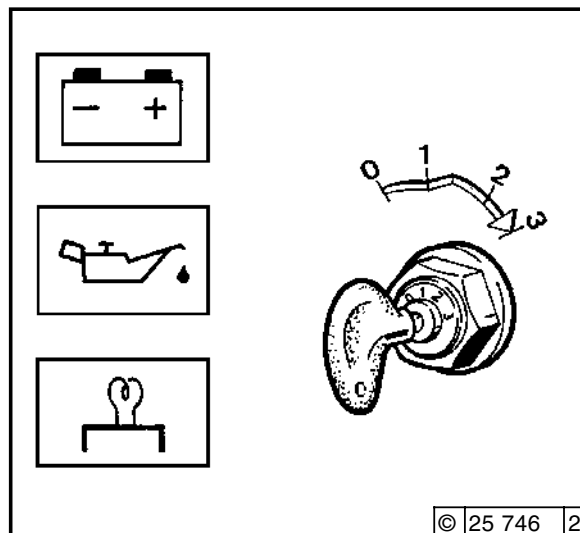


- Insert key
 - Position 0 = no operating voltage
- Turn key clockwise
 - Position 1 = operating voltage
 - Pilot lights illuminate
- Push key in and turn further clockwise against spring pressure
 - Preheat lamp comes on
 - Position 2 = preheat for approx. 60 secs. (holding key*)
 - Preheat lamp extinguishes
 - Position 3 = start
- Release key as soon as engine fires
The pilot lights will go out.

* Fuel particles not burnt during initial combustion in the cylinder are subjected to a second stage combustion process for approx. 3 minutes in order to let the exhaust gases become more transparent in the start-up phase.

with cold start assistance/glow lamps

FR 20/30 = 11 and 23 Volt



- Insert key
 - Position 0 = no operating voltage
- Turn key clockwise
 - Position 1 = operating voltage
 - Pilot lights illuminate
- Push key in and turn further clockwise against spring pressure
 - Preheat lamp comes on.
 - Position 2 = preheat for approx. 20-30 secs., (holding key*)
 - Preheat lamp extinguishes
 - Position 3 = start
- Release key as soon as engine fires
The pilot lights will go out

* Fuel particles not burnt during initial combustion in the cylinder are subjected to a second stage combustion process for approx. 3 minutes in order to let the exhaust gases become more transparent in the start-up phase.

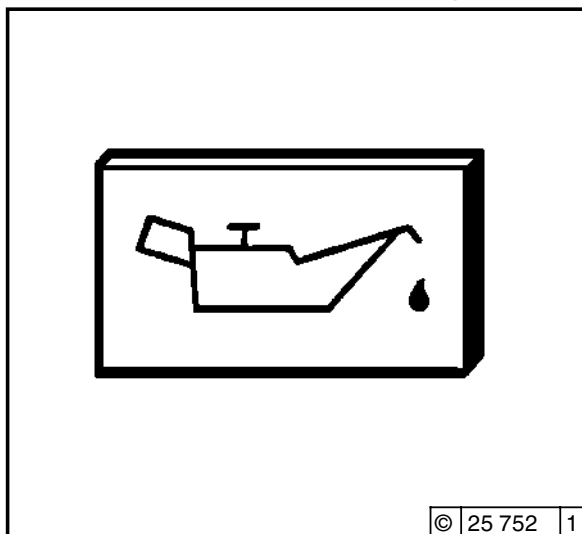
Engine Operation

3.3 Monitoring Operation

3

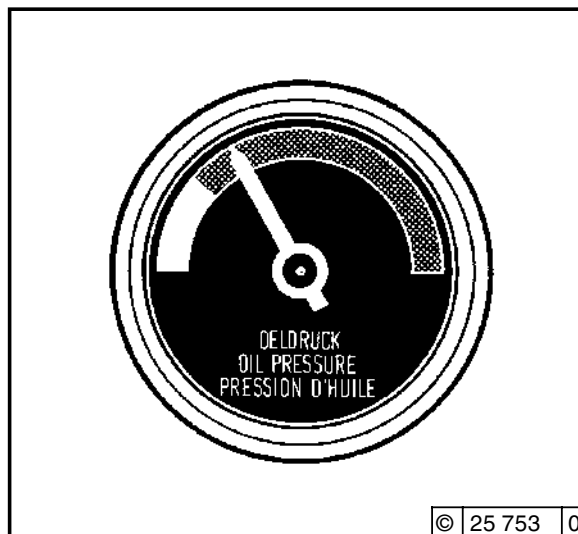
3.3.1 Engine Oil Pressure

Oil pressure pilot lights



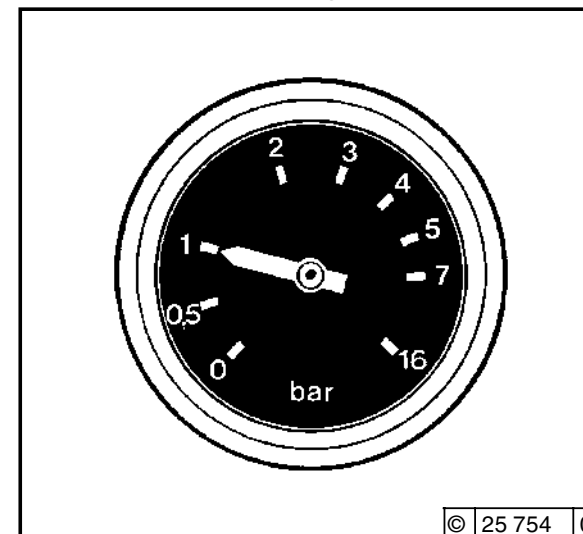
- The oil pressure pilot light comes on with operating voltage on and engine off.
- The oil pressure pilot light should go out when the engine is running.

Oil Pressure Indicator



- The pointer must remain in the green sector over the entire operating range.

Oil Pressure Gauge



- The pointer of the oil pressure gauge must display the minimum oil pressure (see 9.1).

3.3 Monitoring Operation

Engine Operation

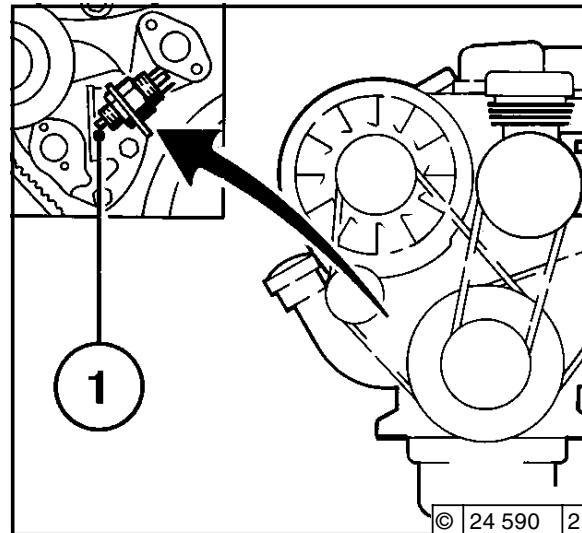
3.3.2 Engine temperature

Engine Temperature Gauge



- The engine temperature gauge pointer should remain in the green sector most of the time. It should rarely enter the yellow-green sector. If the pointer enters the orange sector, the engine is overheating. Turn off and establish the cause from the Fault Table (see 7.1).

3.3.3 Cooling fan drive



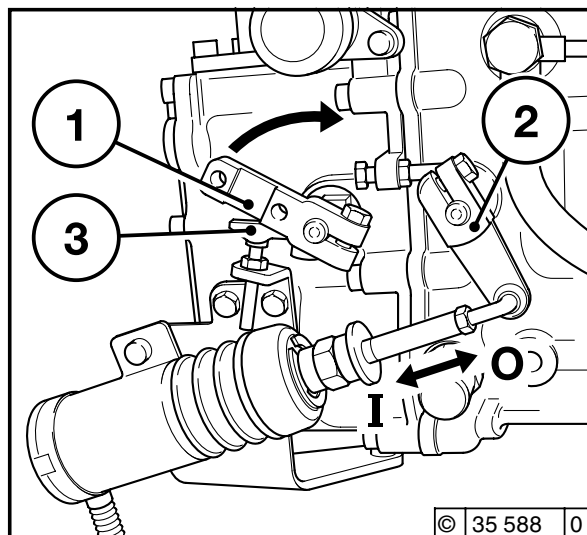
- When the V-belt is torn, the pressure pin 1 of electrical switch is actuated by the tension roller and an audio signal or a light signal is emitted. Switch off the engine immediately to avoid overheating.

Engine Operation

3.4 Shutting Off

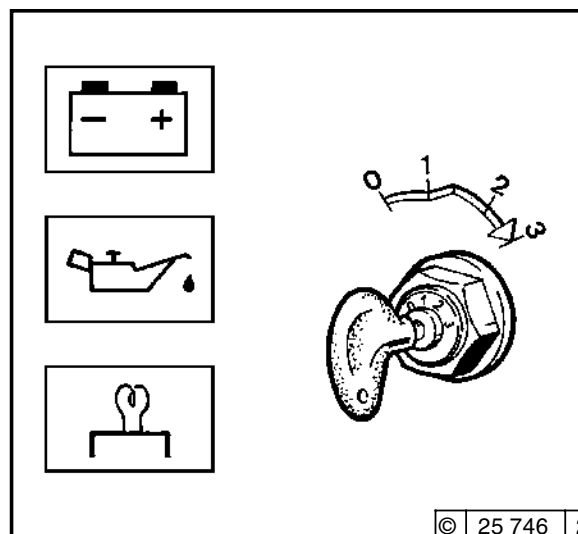
3

3.4.1 Mechanical shut-off



- Move speed adjustment lever 1 to low idle.
- Move shut-off lever 2 in the direction of “0” until the engine comes to a stop. The charge pilot light and the oil pressure pilot light will come on when the engine stops.
- Turn key counterclockwise (to position 0) and remove. The pilot lights will go out.
- Concerning electrical shut-off or power failure, the shut-off lever 2 is disabled by the solenoids until the engine stops. The charge pilot light and the oil pressure pilot light illuminate when the engine stops.
- Turn key counterclockwise (to position 0) and remove. The pilot lights will go out.

3.4.2 Electrical shut-off Ignition key



- Turn key counterclockwise (to position 0) and remove. The pilot lights will go out.

If possible, do not suddenly switch off the engine when under full load.

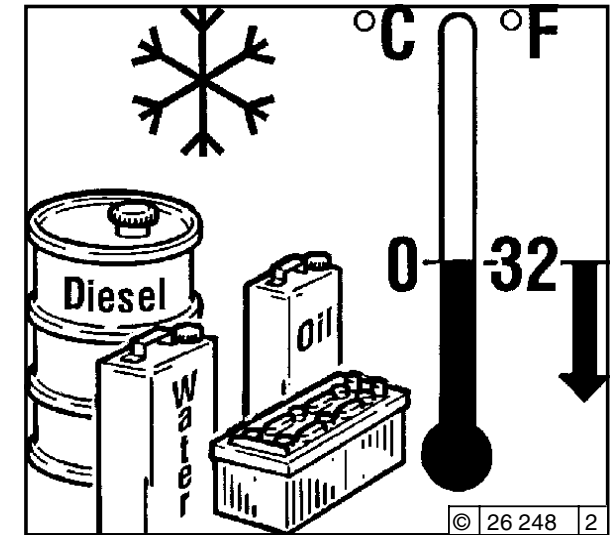
3.5 Operating Conditions

Engine Operation

3.5.1 Winter Operation

- **Lube Oil Viscosity**
 - Select the oil viscosity (SAE grade) according to the ambient temperature when starting the engine, see 4.1.2.
 - Increase oil change frequency when operating below -10°C , see 6.1.1.
- **Battery**
 - Efficient cold starting requires the battery to be well-charged, see 6.7.1.
 - The starting limit temperatures can be lowered by $4\text{--}5^{\circ}\text{C}$ by heating the battery up to about $+20^{\circ}\text{C}$. (To do so, remove the battery and store in a warm place).
- **Diesel Fuel**
 - Use winter-grade diesel fuel for operation below 0°C , see 4.2.2
- **Additional Maintenance Work**
 - Drain the sludge from the fuel tank once a week. (Unscrew the sludge drain plug)
 - If necessary, allow the oil in the oil bath air cleaner and the engine oil to settle at the ambient temperature.
 - Below -20°C , after removing the starter if necessary, smear the ring gear on the fly wheel via the pinion bore from time to time with cold-resistant grease (e.g. Bosch FT 1 V 31 grease).
- **Cold Start Assistance**

At temperatures near or below freezing point, use sheathed glow plugs if necessary, see 3.2.1. This not only lowers the starting limit temperature, but provides easier starting at temperatures normally not requiring a starting aid.



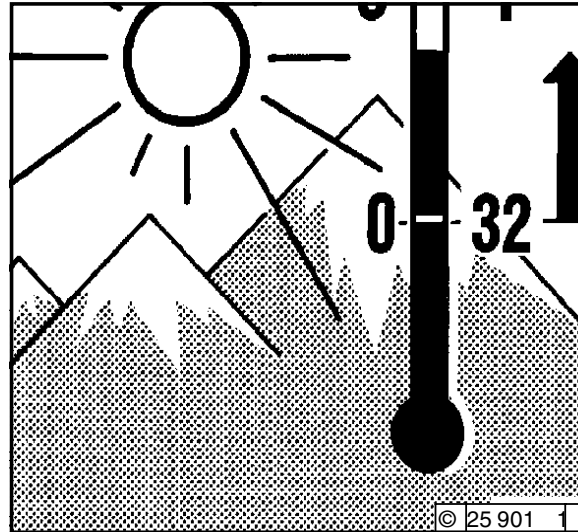
Engine Operation

3.5 Operating Conditions

3

3.5.2 High Ambient Temperature, High Altitude

- Air density decreases as altitude or ambient temperature increase. As a result of this, the engine's maximum output, the quality of the exhaust gas, the temperature level and, in extreme cases, starting behaviour, are impeded. Under transient conditions, the engine can be used at altitudes up to 1000 m and temperatures up to 30 °C. If the engine is to operate under more severe conditions (at higher altitudes or temperatures), it will be necessary to reduce the injected fuel quantity and thus, engine power.
- If you have any doubts about engine operation under these or similar conditions, ask your engine or equipment supplier whether the engine has been derated in the interests of reliability, service life and exhaust gas quality (smoke). Otherwise contact DEUTZ SERVICE.



4.1 Lube Oil

4.2 Fuel

Operating Media

4.1 Lube Oil

4

4.1.1 Quality

Lube oils are differentiated according to their performance and quality class. In common use are specifications named after the API (American Petroleum Institute) and ACEA (European Engine Oil Sequences).

Approved API Oils:

At least: CF-4

Approved ACEA Oils:

At least: E1-96

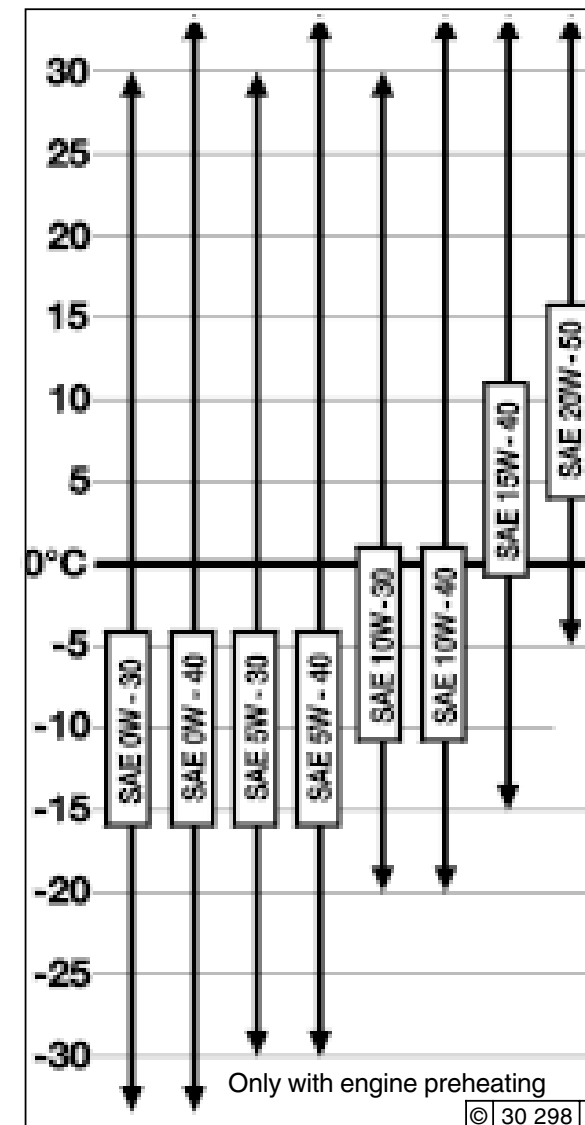
It is recommended to operate the engines with **Deutz Oil TLX10W-40FE Europe**. If this is not available, use the appropriate oil as described above.

4.1.2 Viscosity

As the viscosity of the lube oil is dependent on temperature, the choice of SAE grade should be governed by the ambient temperature prevailing at the engine operating site. Optimum operating behaviour will be attained if you take the accompanying oil viscosity diagram as a guide.

Should the temperature fall temporarily below the limits of SAE grade selected, cold starting may be affected but the engine will not be damaged. In order to keep wear to a minimum, do not exceed application limits for extended periods of time.

Oil changes dictated by the seasons can be avoided by using multi-grade lube oils. Multi-grade oils, particularly light-flowing oils, also reduce fuel consumption.



* Oil change intervals, see 6.1.1
Oil capacities, see 9.1

4.1 Lube Oil

Operating Media

4.1.2.1 Specific lube oil definitions

Turbocharged engines with increased output and engines with high capacity.

For the following engines, or applications:

- for engines with an output >141kW the oils listed in the following table are to be used.

Firstly, these oils are of high quality in accordance with ACEA or API. Additionally, these oils are mainly partly synthetic, some even fully synthetic (5W-40) and thus achieve thermal stability if required for the application and sediments are less likely if the crankcase ventilation is closed in the turbocharger and in the air-intake lines.

Emission optimised engines for commercial vehicles from EURO II and mobile driven machines from position 2, corresponding to the following emission requirements:

- from EURO II, the 88/77/EEC and 91/542/EEC guidelines for commercial vehicles in Europe,
- from position 2, the 97/68/EC guidelines for mobile driven machines in Europe
- from position 2, the US non-road engines guidelines, only the following oil qualities are permitted:
 - ACEA E3-96 and ACEA E4-98 for requirements a) and b)
 - API CG-4 and API CH-4 for the requirements c)

Lube oil for engines with increased output and engines with high output			
Manufacturer	Lube oil type	SAE Class	Availability
DEUTZ	Deutz TLX Oil	10W-40FE	Europe
AGIP	Agip Sigma Ultra TFE	10W-40	worldwide
AGIP	Autol Valve Ultra FE	10W-40	Germany
ARAL GmbH	Aral MegaTurboral	10W-40	worldwide
ARAL GmbH	Aral SuperTurboral	5W-30	worldwide
BAYWA	BayWa Super Truck 1040 MC	10W-40	South Germany
BAYWA	BayWa Turbo 4000	10W-40	South Germany
Castrol GmbH	Castrol SYNTRUCK	5W-40	Europe, North America, Brazil, Argentina, Australia, South Africa,
Castrol GmbH	Castrol DYNAMAX	7,5W-40	Europe, North America, Brazil, Argentina, Australia, South Africa
CHEVRON	Chevron Delo 400 Synthtic	5W-40	North America
ESSO	Essolube XTS 501	10W-40	Europe
FINA	FINA KAPPA FIRST	5W-30	Europe
FINA	FINA KAPPA ULTRA	10W-40	Europe
FUCHS DEA	DEA Cronos Synth	5W-40	Germany, Europe
FUCHS DEA	DEA Cronos Premium LD	10W-40	Germany, Europe
FUCHS DEA	Fuchs Titan Cargo MC	10W-40	worldwide
FUCHS DEA	DEA Cronos Premium FX	10W-40	Europe
FUCHS DEA	Fuchs Titan Unic Plus MC	10W-40	worldwide
MOBIL OIL	Mobil Delvac 1 SHC	5W-40	Europe, South East Asia, Africa
MOBIL OIL	Mobil Delvac 1	5W-40	worldwide
MOBIL OIL	Mobil Delvac XHP Extra	10W-40	Europe, South East Asia
BP OIL International	BP Vanellus HT Extra	10W-40	Europe
Shell International	Shell Myrina TX /	5W-30	Europe, label country-specific, various
	Shell Rimula Ultra		
	Shell International		
	Shell Myrina TX /		
TOTAL	TOTAL RUBIA TIR 86000	10W-40	Europe, label country specific, various
lube oil refinery Salzbergen GmbH	Wintershall TFG	10W-40	Europe

The table can be extended if required.

Operating Media

4.2 Fuel

4

4.2.1 Quality

Use commercially available diesel fuel with less than 0.5 % sulphur content. If the sulphur content is higher, oil change intervals should be reduced (see 6.1.1).

The following fuel specifications / standards are approved: (also see TR 0199-3002)

● Diesel fuel

- DIN EN 590
- BS 2869: A1 and A2
(with A2, take note of the sulphur content)
- ASTM D 975-88; 1-D and 2-D
- NATO Code F-54 and F-75
- ISO 8217 DMX
- ISO 8217 DMA

● Light fuel oils

in accordance with DIN 51603
ASTM D 396; 1 and 2
BS 2869 Class D

● Jet fuel

- F34/F35/F44 (Kerosene)
- F54 (corresponds to diesel fuel in accordance with DIN EN 590)
- XF 63 (corresponds to F34+F35 with additives)

● Bio diesel fuel

- in accordance with DIN 51606- FAME
- Exhaust emission values which may be determined in the case of type approval tests always refer to the reference fuel prescribed by the authorities for the type approval test.

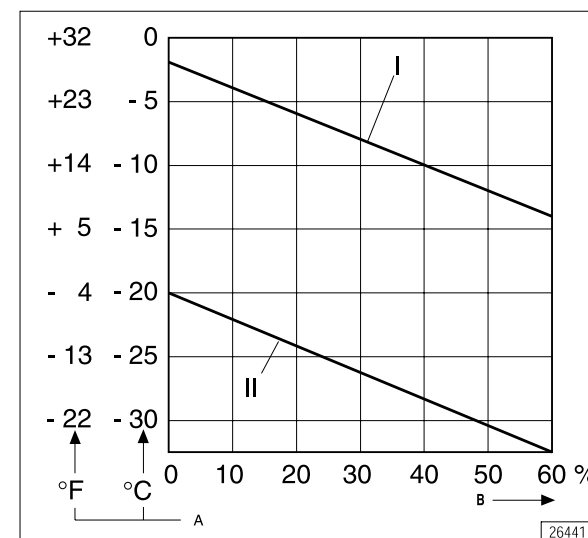
4.2.2 Winter Fuel

Waxing may occur at low temperatures, clogging the fuel system and reducing engine efficiency. If the ambient temperature is less than 0 °C, winter-grade fuel (suitable down to -20 °C) should be used. (This fuel is available from the filling stations well in advance of the cold months).

- Kerosene must be added at temperatures below -20 °C. The relevant percentages are given in the adjacent diagram.
- Special diesel fuels may be used in arctic climatic zones up to -44 °C.

If summer-grade diesel fuel must be used at temperatures below 0 °C, up to 60% kerosene can be added (see diagram).

In most cases, adequate resistance to cold can be obtained by adding a flow improver (additive). Please ask your DEUTZ partner.



Legend:

I	Summer-grade diesel fuel
II	Winter-grade diesel fuel
A	Ambient temperature
B	Percentage of kerosene added



diesel fuel should never be mixed with petrol (normal or super petrol)



Mix in tank only! Fill with the appropriate amount of kerosene first, then add the diesel fuel.

5.1 Maintenance Plan

5.2 Maintenance Schedules

5.3 Maintenance Work Completed

Routine Maintenance

5.1 Maintenance Schedule

5

check = ● adjust = ○ clean = ◆ replace = ■										<div>Industrial engines</div> <div>The specified engine maintenance values are permissible recommended maximums. Depending on usage, reduced maintenance intervals may be necessary, comply with the unit manufacturer's operating instructions.</div> <div># Maintenance must only be carried out by authorised service personnel</div>		Section
prior to or during 1st trial run, check 2x daily during the breaking in phase or when commissioning new and overhauled engines												
every 10 hours of operation or daily												
In hours of operation (HO) every										Operation		
E10	E20	E30 125	E40 250	E50 500	E60 1000	E70 12000	years					
							1	2				
●	●								Top up lube oil if necessary (also with separate container)		6.1.2/3.3.4	
		■	■	■					Lube oil (oil change intervals depending on engine use), see TR 0199-99-3002		6.1.1/6.1.2	
		■	■	■					Oil filter cartridge (at each lube oil change)			
	●								Oil bath air filter		6.3	
				■					Bypass – oil filter		6.1.4	
					■				Fuel filter cartridge		#	
					◆				Fuel pre-cleaner		4.2/ 6.2.2	
	●				◆				Intake air cleaner/dry type air cleaner (If available, maintain according to maintenance indicator)		6.4.3 /6.4.4	
		●							Battery and cable connectors		6.7.1	
			●						Engine monitoring system, warning system		3.3 #	
				○	○				Valve clearance (set if necessary, earlier if noises occur)		6.6.1#	
		●						■	V-belts (retension or replace if necessary)		6.5.1	
				●				■	Sheathed glow lamps		6.9.3	
●									Check engine for leaks (visual inspection)		–	
					●				Engine suspension (replace if damaged)		9.2	
					●				Fastenings, hose connections / clamps		6.9.1	
						■			Basic overhaul		#	

5.1 Maintenance Schedule

Routine Maintenance

check = ● adjust = ○ clean = ◆ replace = ■										<div>Additions and modifications for engines with EPA approval</div> <div>The specified engine maintenance values are permissible recommended maximums. Depending on usage, reduced maintenance intervals may be necessary, comply with the unit manufacturer's operating instructions.</div> <div># Maintenance must only be carried out by authorised service personnel</div>	
max. recommended standard times in operating hours (HO) of all											
prior to or during 1st trial run, check 2x daily during the breaking in phase or when commissioning new and overhauled engines											
every 10 hours of operation or daily											
E10	E20	In hours of operation (HO) every								Operation	Section
		years									
		E30 250	500	E40 1000	E50 2000	E60 3000	E70 4000	1	2		
						■				Injection valve	#
						◆				Intercooler (drain lube oil/condensation)	#
						◆				CPD compressor outlet	#
							■			Basic overhaul of emission related parts	#

Maintenance

5.2 Routine maintenance work plan

5

5.2.1 Routine maintenance work plan

Intervals with/after	Maintenance	Activity levels	Plan executed by:	Comments
50 [OH]	E 10	after operation and E 50 - E 70	authorised specialised staff	
daily	E 20	daily inspection	the user	
250 [OH]	E 25	Inspection	authorised specialised staff	
500 [OH]	E 30	further inspection	authorised specialised staff	
1000 [OH]	E 40	intermediate repair	authorised specialised staff	
3000 [OH]	E 50	further intermediate repair	authorised specialised staff	
6 000 [OH]	E 60	partial repair	authorised specialised staff	
12 000 [OH]	E 70	major repair	authorised specialised staff	

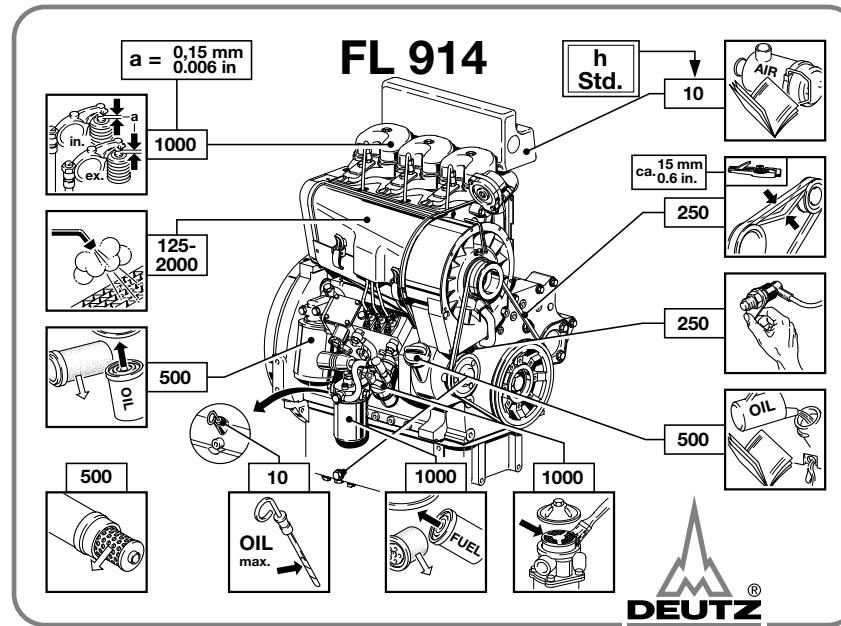
5.2 Maintenance Charts

Routine Maintenance

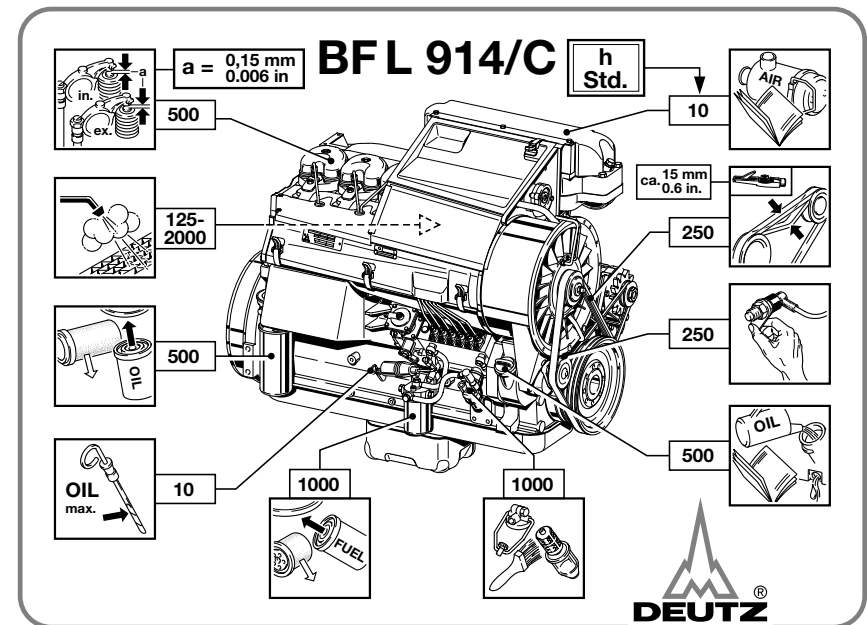
The maintenance charts shown on this page are supplied as self-adhesive labels with each engine. They should be affixed where they can be seen clearly on the engine or driven equipment.

Check that this is the case.

If necessary, ask your engine or equipment supplier for a fresh supply of labels! Routine work should be carried out according to the schedule (see chapter 5.1).



0312 0360 0



0132 0359 0



Stop the engine before carrying out any maintenance work.

APPENDIX A

Routine Maintenance

5.3 Maintenance Work Completed

5

Op. hours	Date	Signature/stamp	Op. hours	Date	Signature/stamp
50-150*			—		
125			250		
375			500		
625			750		
875			1000		
1125			1250		
1375			1500		
1625			1750		
1875			2000		
2115			2250		
2375			2500		
2625			2750		
* following commissioning of new and overhauled engines. Duly completed maintenance jobs can be recorded and signed off in the above chart.					

APPENDIX A

5.3 Maintenance Work Completed

Routine Maintenance

Op. hours	Date	Signature/stamp	Op. hours	Date	Signature/stamp
2875			3000		
3125			3250		
3375			3500		
3625			3750		
3875			4000		
4125			4250		
4375			4500		
4625			4750		
4875			5000		
5125			5250		
5375			5500		
5625			5750		

Duly completed maintenance jobs can be recorded and signed off in the above chart.

APPENDIX A

Routine Maintenance

5.3 Maintenance Work Completed

5

Op. hours	Date	Signature/stamp	Op. hours	Date	Signature/stamp
5875			6000		
6125			6250		
6375			6500		
6625			6750		
6875			7000		
7125			7250		
7375			7500		
7625			7750		
7875			8000		
8125			8250		
8375			8500		
8625			8750		
Duly completed maintenance jobs can be recorded and signed off in the above chart.					

- 6.1 Lubrication System**
- 6.2 Fuel System**
- 6.3 Cooling system**
- 6.4 Combustion Air Filter**
- 6.5 Belt Drives**
- 6.6 Adjustments**
- 6.7 Accessories**
- 6.8 Engine cleaning**
- 6.9 Additional Maintenance Work**

Service and Maintenance

6

6.1.1 Oil change intervals

- The oil change intervals are dependent on the engine application and the quality of the lube oil.
- If the engine runs fewer hours during the year than stated in the table, the oil should be changed at least **once a year**.
- The table refers to the following conditions:
 - For diesel fuel: sulphur content max. 0.5% by weight.
 - Continuous ambient temperatures down to -10 °C (+14 °F).
- If the sulphur content is > 0.5 to 1% or the continuous ambient temperature below the oil change intervals must be halved.
- In the case of fuels with a sulphur content higher than 1%, contact your Service representative.

Change the oil with the engine off but still warm (lube oil temperature approx. 80 °C).

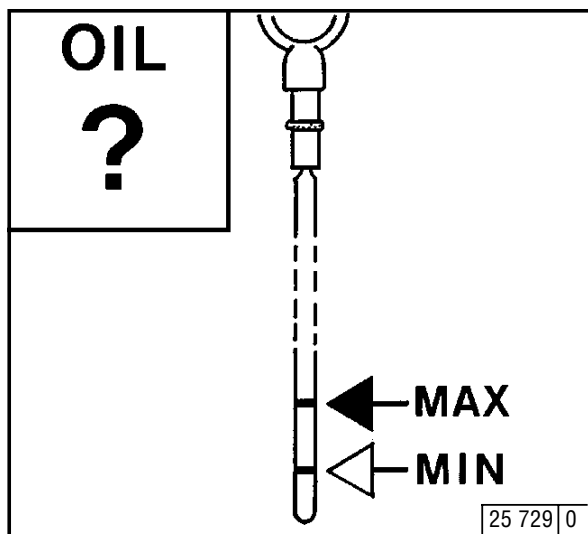
Engines for installation			Lube oil change intervals in HO		
Lube oil quality	API specification		Naturally aspirated engines	Turbocharged engines	
			CF-4/CH-4/ CG-4	CF-4	CG-4 / CH-4
	ACEA-spezifikation		E1+E2-96	E1+E2-96	E3-96/E4-98
Normal oil requirement, e.g.:			500	250	500
Road vehicles, cranes, construction machines, ships electrical modules, pumps, railway vehicles.					
High oil requirement, e.g.:					
Combines, emergency pumps, underground mining units, sweeping machines, winter service vehicles, emergency power units.			250	125	250
Vehicle engines			Lube oil change intervals in km		
Lube oil quality	API specification		Naturally aspirated engines	Turbocharged engines	
			CF-4/CH-4/ CG-4	CF-4	CG-4 / CH-4
	ACEA-spezifikation		E1+E2-96	E1+E2-96	E3-96/E4-98
Service group	Year's kilometrage km	medium driving speed approx. km/h	10 000	5 000	10 000
I	> 30 000	20			
II	30.000 -100.000	40			
III	< 100 000	60	30 000	15 000	30 000

6.1 Lubrication System

Service and Maintenance

6.1.2 Checking Oil Level /
Changing Engine Oil

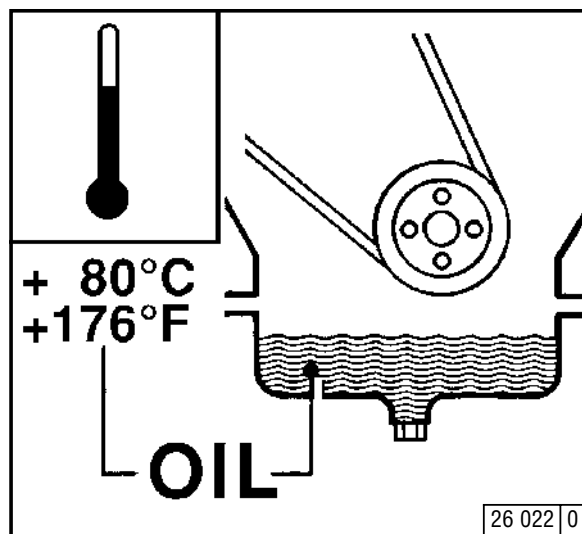
6.1.2.1 Checking Oil Level



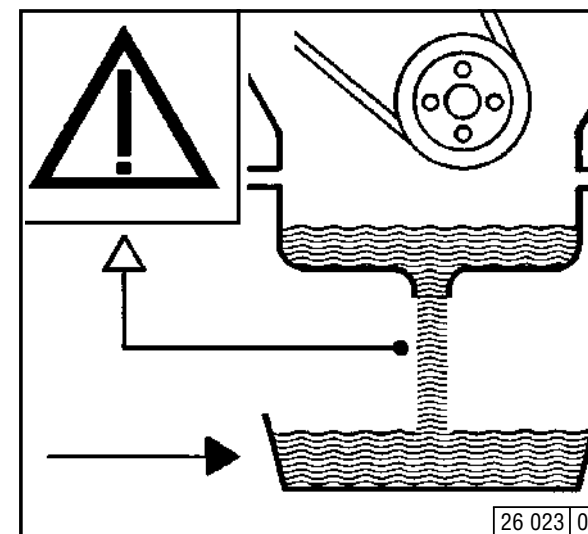
- Ensure that the engine or vehicle is on a level surface.
- – **Warm engine**
- Switch off engine, wait 5 minutes and check the oil level
- – **Cold engine**
Check the oil level
- Remove the dipstick
- Wipe off with a non-fibrous, clean cloth.
- Insert up to the stop and pull out again.
- Check oil level, if required top up to the “**MAX**” level
 - If the oil level is just above the “**MIN**” mark, it should be topped up.

The oil level must not drop below the “**MIN**” mark.

6.1.2.2 Changing Engine Oil



- Run the engine warm
- Ensure that the engine or vehicle is on a level surface
 - Lube oil temperature approx. 80°C.
- Switch off the engine.

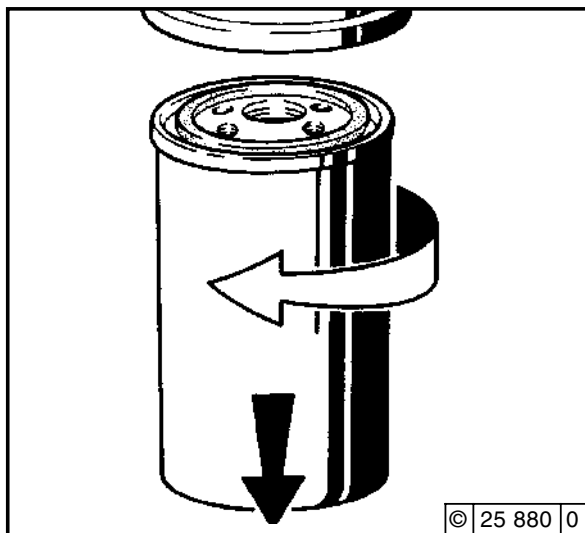


- Place an oil tray beneath the engine
- Unscrew drain plug.
- Drain oil.
- Fit oil drain plug with new gasket and tighten firmly (for torque, see 9.2).
- Fill with lube oil
 - For grade/viscosity, see 4.1.
 - For quantity, see 9.1.
- Check oil level, see 6.1.2.1

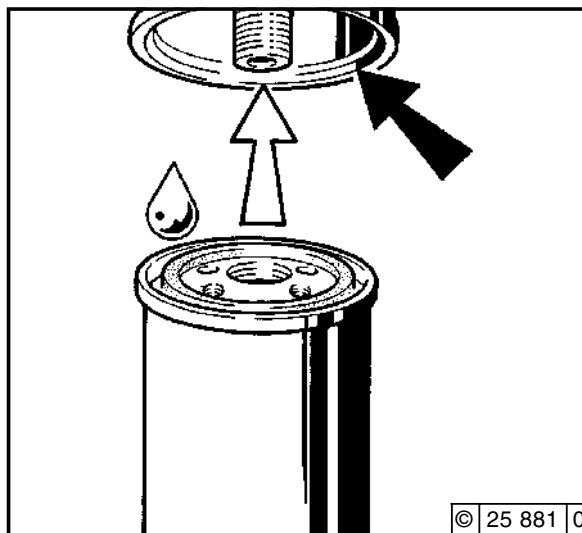


Be careful when draining hot oil - danger of scalds! Do not let used oil run into the soil but catch it in a container ready for proper disposal.

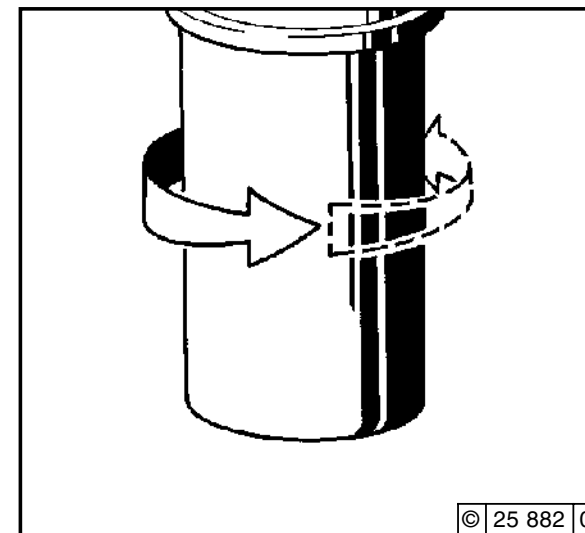
6.1.3 Replace Oil Filter



- Undo the lube oil filter cartridge using a commercial tool and spin off.
- Catch any escaping oil.



- Clean any dirt from the filter carrier sealing surface.
- Lightly oil the rubber gasket of the new lube oil filter cartridge.
- Manually screw in the new cartridge until the gasket is flush.



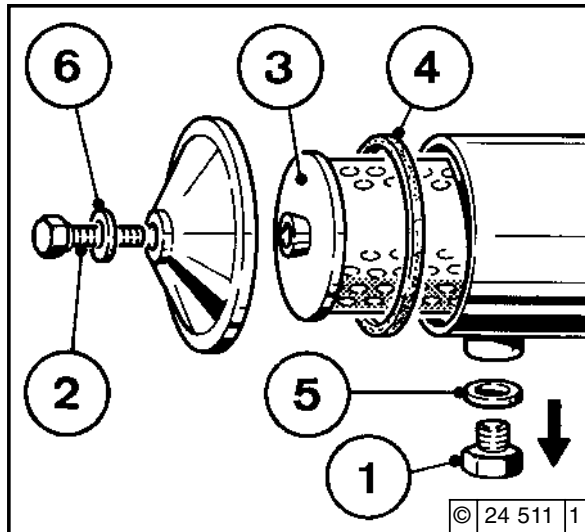
- Tighten the lube oil filter cartridge with another half-turn.
- Check the oil level, see 6.1.2
- Check oil pressure, see 3.3.1.
- Check lube oil filter cartridge seal for leaks.



Caution is required in the case of hot oil: Risk of scalding! Please dispose of oil in an environmentally-friendly manner!

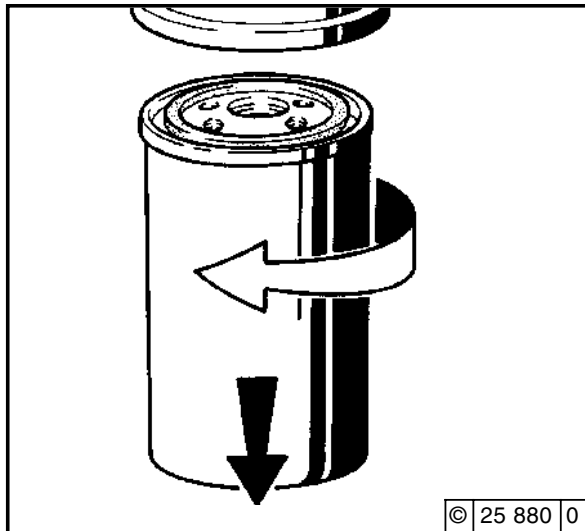
6.1 Lubrication System

Service and Maintenance

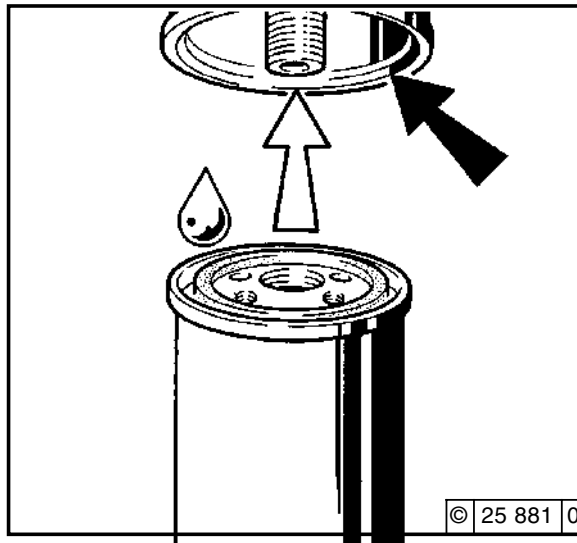
6.1.4 Change bypass-oil filter
use

- Remove oil drain screw 1 and let the oil run out.
- Catch any escaping oil.
- Remove tensioning screw 2. Remove cover.
- Remove soiled filter 3. Clean filter casing.
- Check cover 4 for leaks, and replace if necessary.
- Screw in oil drain screw with a new seal ring 5.
- Insert new filter.
- Screw on cover with seal ring 6.
- During trial, observe oil pressure and check for leaks.

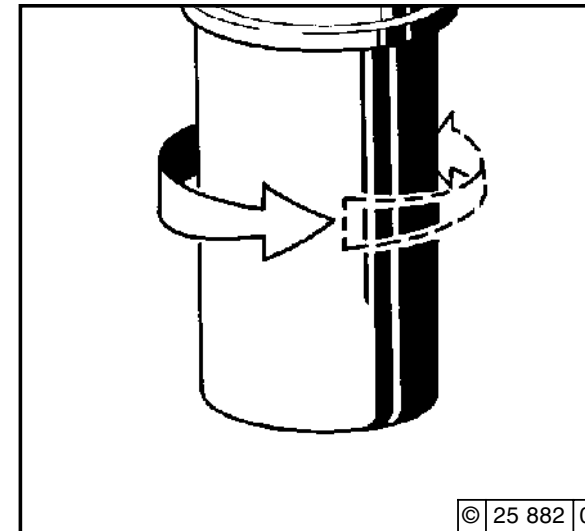
6.2.1 Replace Fuel Filter



- Close the fuel shut-off valve.
- Undo fuel filter cartridge with commercial tool and spin off.
- Catch any escaping fuel.



- Clean any dirt from the filter carrier sealing surface.
- Apply light film of oil or diesel fuel to the rubber gasket of the new fuel filter cartridge.
- Manually screw in the new cartridge until the gasket is flush.



- Tighten the fuel filter cartridge with a final half-turn.
- Open fuel shutoff valve.
- Check for leaks.



Keep naked flames away when working on the fuel system. Do not smoke!

The fuel system does not need to be bled.

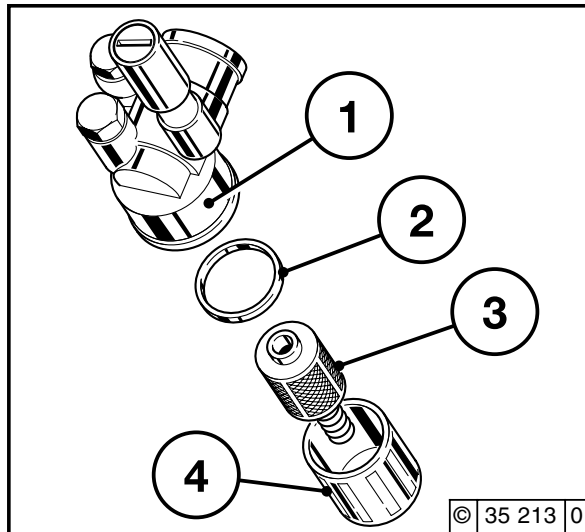
6.2 Fuel System

Service and Maintenance

6.2.2 Fuel precleaning

Clean fuel filter

“Motorpal” model



- Close the fuel shut-off valve.
- Screw out and remove filter cap 4.
- Catch any escaping fuel.
- Remove strainer 3 and clean with fuel.
- Remove seal ring 2.
- Clean filter casing 1 with fuel.
- Screw on filter cap 4 and strainer 3 with new seal 2.
- Bleed fuel system (see 3.1.4).
- Open fuel shutoff valve.
- Check for leaks.



Keep naked flames away when working on the fuel system. Do not smoke!

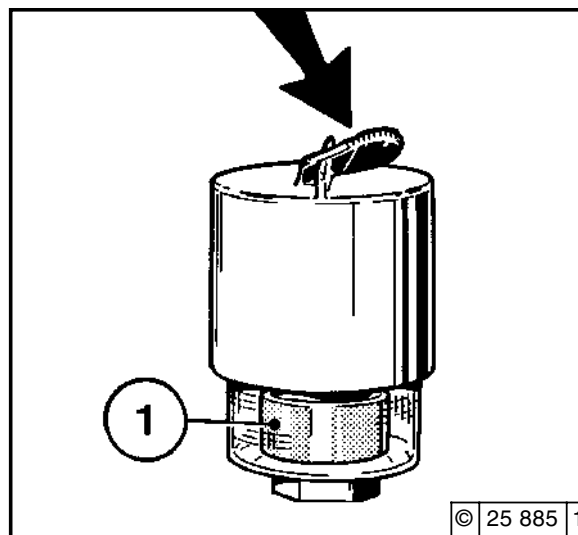
6.3.1 Cleaning Intervals

- The amount of contamination in the cooling system depends on the engine application.
- Oil and fuel residues on the engine increase the risk of contamination. Therefore pay special attention to leaks if the engine is used in dusty environments.
- Serious contamination can occur, for example:
 - On construction sites where there is a high level of air-borne dust.
 - In harvesting application where there are high concentrations of chaff and chopped straw in the vicinity of the machine.
- Because applications vary, cleaning intervals have to be determined from case to case. The cleaning intervals given in the table on the right can be used as a guide.

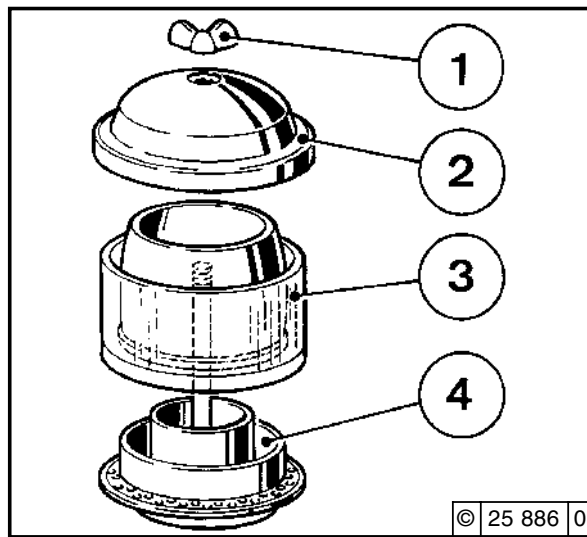
Checking or cleaning intervals	Engine application
Standard values OH	
2000	Ships, electrical modules in enclosed areas, pumps
1000	Vehicles on paved roads
500	Tractors, fork-lift trucks, drivable electric units.
250	Vehicles on construction sites and unpaved roads, construction machines compressors, underground mining units
125	Agricultural machines, tractors in harvesting application

6.4.1 Cleaning Intervals

- The amount of dirt in the air cleaner depends on the amount of dust in the air and the size of the air cleaner used. If a high level of dust is anticipated, a cyclone-type precleaner can be fitted to the air cleaner.
- Cleaning intervals will have to be determined from case to case.
- If dry type air filters are used, cleaning should only be carried out according to the service indicator or service switch.
- Air cleaner servicing is needed when
 - **Service indicator**
the red signal 1 is fully visible when the engine is off.
 - **Service switch**
the yellow pilot light comes on when the engine is running.
- After carrying out service work, reset the signal by pressing the button on the service indicator. The service indicator is now ready for operation again.

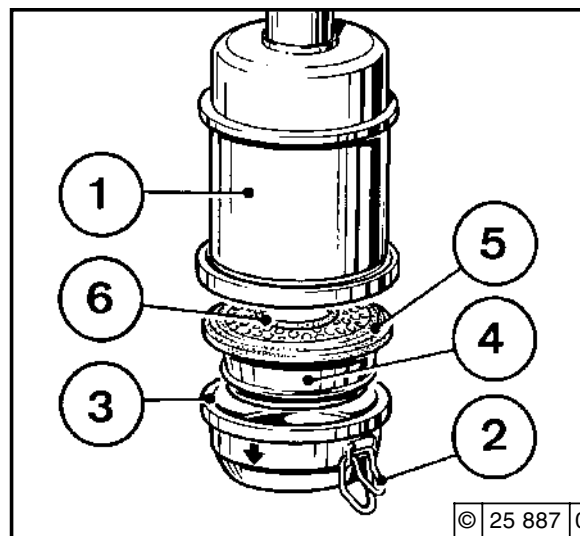


6.4.2 Emptying Cyclone Type Precleaner



- Undo wing nut 1 and remove cover 2.
- Remove collector bowl 3 from lower section 4 and empty. Clean leaves, straw and other foreign matter from lower section of pre-cleaner.
- Reposition collector bowl 3 onto lower section 4, fasten cover 2 in place by tightening wing nut 1.

6.4.3 Clean Oil Bath Air Filter



- Turn engine off and wait about 10 minutes for the oil to drain from filter housing 1.
- Loosen quick fasteners 2 and remove oil cup 3 with filter element 4; if necessary, loosen filter element with the aid of a screwdriver at the separating point. Do not damage rubber gasket 5!
- Remove dirty oil and sludge. Clean oil cup.
- Clean filter element 4 in diesel fuel and allow to drip-dry.

- Clean filter housing 1 if very dirty.
- Inspect and replace rubber gasket 5 and 6 if necessary.
- Fill oil cup with engine oil up to the mark (arrow) (for viscosity, see 4.1.2).
- Refit oil cup and element to filter housing and secure with snap clips.

Never fill collector bowl with oil. Replace collector bowl if damaged.

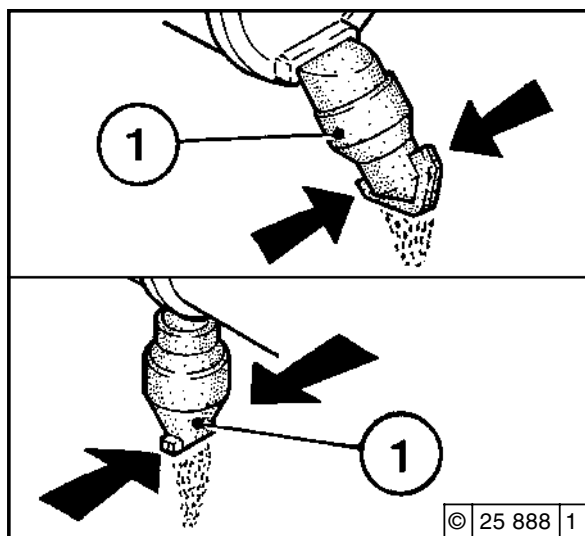


Never clean filter with gasoline!
Dispose of old oil in accordance
with environmental regulations!

6.4 Combustion Air Filter

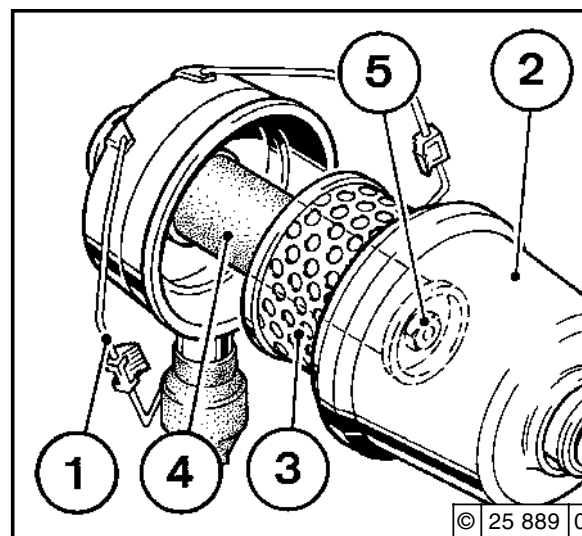
Service and Maintenance

6.4.4 Dry type air cleaner Dust discharge valve



- Empty dust discharge valve 1 by pressing apart lips of discharge slot as indicated by arrows.
- Clean discharge slot from time to time.
- Remove any caked dirt by pressing together the upper section of the valve.

Filter Cartridge



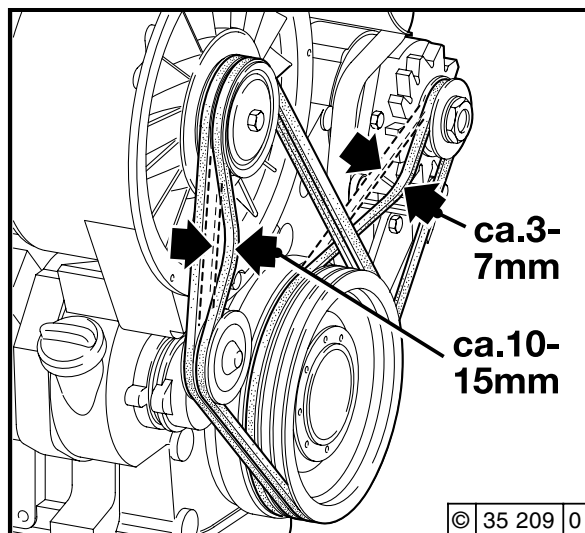
- Undo clip fasteners 1.
- Take off hood 2 and remove cartridge 3.
- Clean cartridge (replace at least once a year).
- Clean cartridge 3.
Blow out using dry compressed air (max. 5 bar), (or in difficult cases, tap out, taking care not to damage the cartridge, or wash according to manufacturer's instructions).
- Through regular removal and replacement, the gaskets on the filter cartridge can become damaged. Check paper filter (light showing through) and gaskets for damage. Replace if necessary.

- After five cleaner services (or after two years at the latest), replace safety cartridge 4 (never clean).
To do so:
 - Undo hex. nut 5 and remove cartridge 4.
 - Install new cartridge, insert and tighten hex nut.
- Install cartridge 3, replace hood 2 and do up clip fasteners 1.

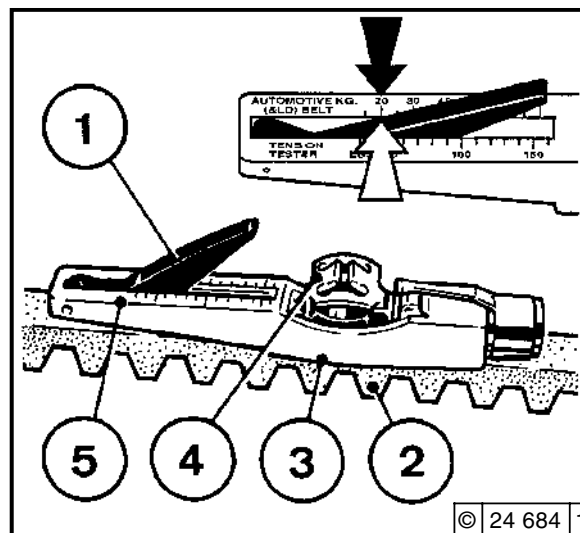


Never clean filter cartridge with gasoline or hot fluids.

6.5.1 Check V-belts



- Visually inspect entire V-belt for damage.
- Replace damaged V-belts.
- After installing new belts, run engine for 15 minutes, then check belt tension.
- To check the tension of the V-belt, use a tension gauge (see 9.3).
 - Place indicator arm 1 into gauge.
 - Position guide 3 on V-belt 2, midway between the pulleys, with flange 3 on bottom of gauge against the edge of belt.
 - Push slowly on the black pad 4 at right angles to V-belt 2 until the spring is heard or felt to trigger.
 - Carefully remove the gauge without altering the position of the indicator arm 1.



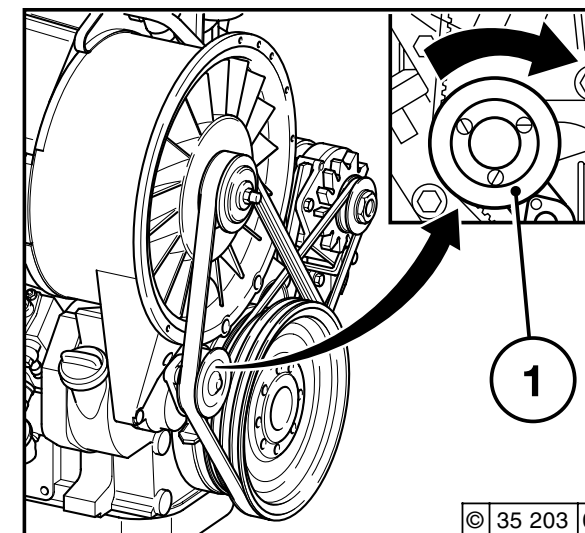
Read off the value where the indicator arm 1 intersects scale 5 (arrow). For settings, see 9.1.

- If necessary, retension belt and measure again.



Check, tension and change belts only with the engine off. Reinstall V-belt guard

6.5.2 Fan V-belt



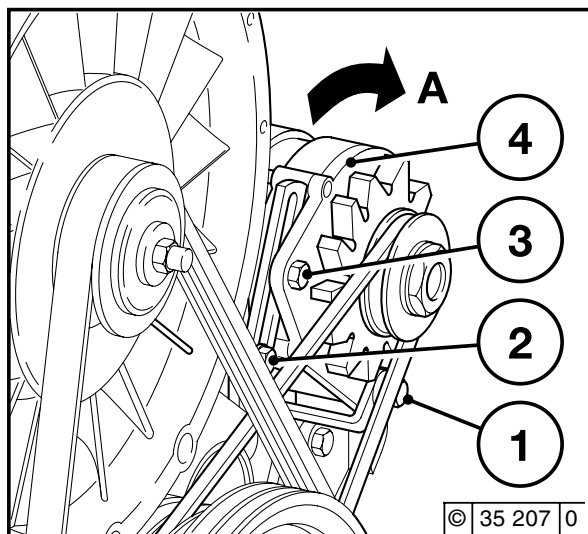
- To replace the tension roller 1, press inwards with a commercial tool and remove the V-belt.
- Position new ribbed V-belt.

Retension V-belt after it has ran for 15 minutes.

6.5 Belt Drives

Service and Maintenance

6.5.3 Alternator belts

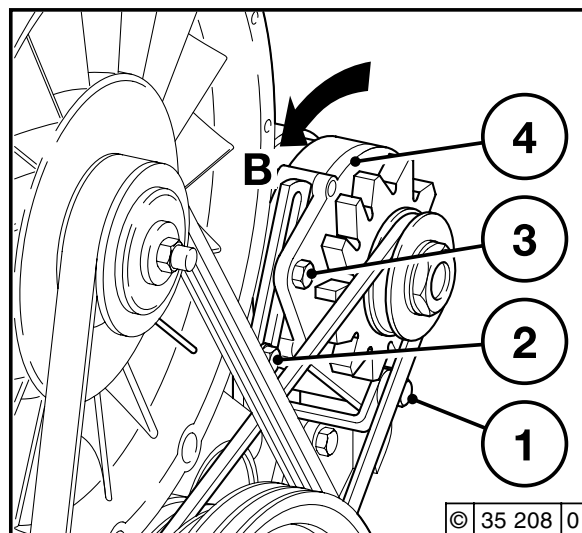


- Loosen bolts 1, 2 and 3 slightly.
- Press alternator 4 outwards in direction of arrow A until correct belt tension is achieved.
- Retighten bolts 1, 2 and 3.



Check, tension and change belts only with the engine off. Reinstall V-belt guard.

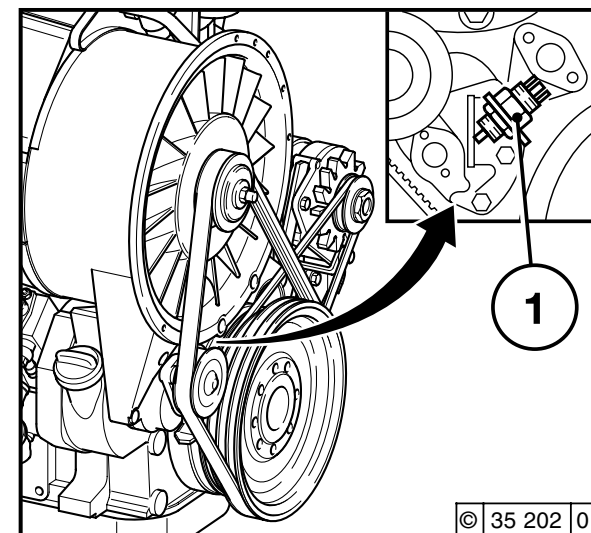
6.5.4 Change alternator belt



- Remove fan belt, as shown in 6.5.2.
- Slacken off bolts 1, 2 and 3.
- Swing alternator inwards in the direction of arrow B.
- Remove and replace belt.
- Swing alternator 4 outwards in direction of arrow A until correct belt tension is achieved.
- Retighten bolts 1, 2 and 3.
- Fit fan belt.

Retension V-belt after it has ran for 15 minutes.

6.5.5 Check warning system

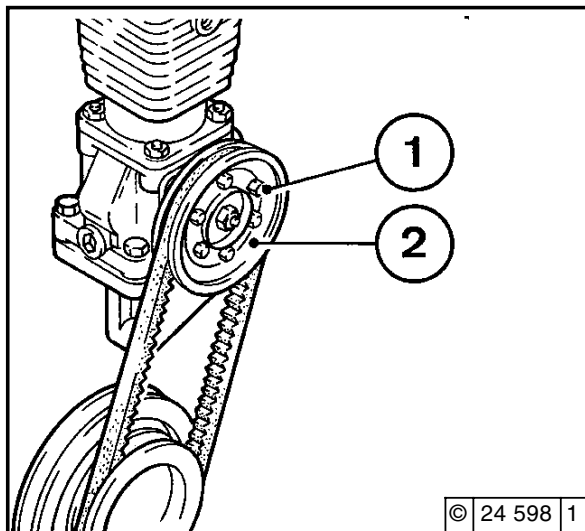


- When the V-belt is torn, the pressure pin 1 of electrical switch is actuated by the tension roller and an audio signal or a light signal is emitted.
- Check the function by pressing pin 1.

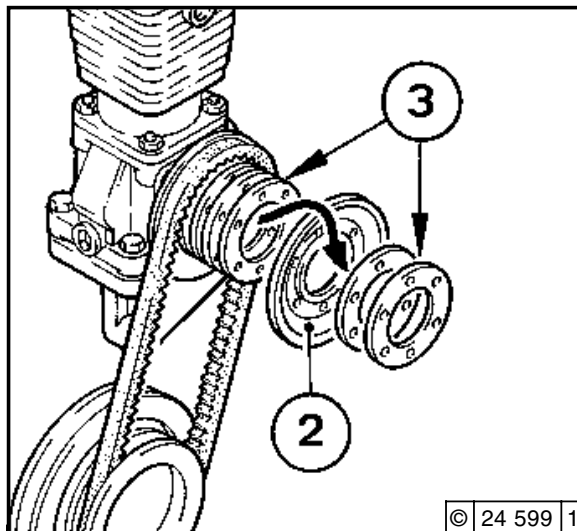


Only check function when the engine is off!

6.5.6 Tensioning or changing V-belts



- Unscrew hex screw 1.
- Remove outer belt pulley half 2.
- Replace V-belt if necessary.



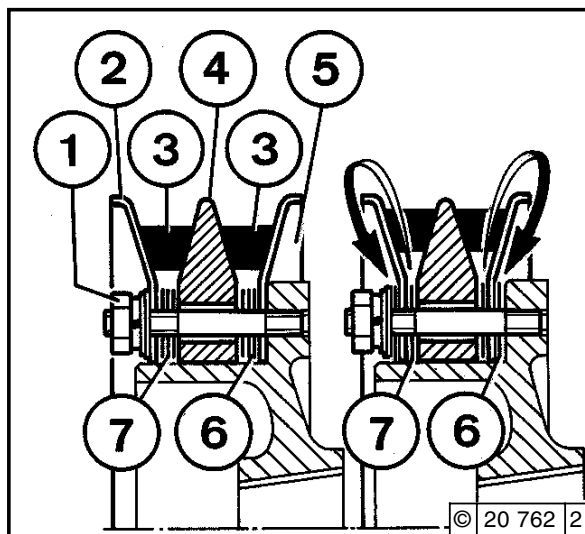
- In order to retension, remove one or more inner washers 3. Place the removed washers on the outside on the removed belt pulley half 2.
- Tighten screw 1 again. Whilst tightening, turn engine over simultaneously in order to prevent crushing the V-belt.

After installing new belts, run engine for 15 minutes, then check belt tension.

6.5 Belt Drives

Service and Maintenance

6.5.7 Air compressor model with dual belts



- Undo hex nut 1, remove V-belt pulley half 2, V-belt 3 and inner washer kit 7.
- Remove inner washers 4, posterior V-belt 3, inner washer kit 6 and pulley half 5.
- To retension, remove one or more inner washers from kits 6 and 7. Place removed washers in front of or behind pulley half 2 to ensure belt alignments. Always remove only the same number of washers from each kit.
- For installation, now proceed in the reverse order. Whilst tightening the nut 1, turn engine over simultaneously in order to prevent crushing the V-belt.

If one belt locks or is damaged, always replace both belts. The difference of length between the new belts may not exceed 0.15%.

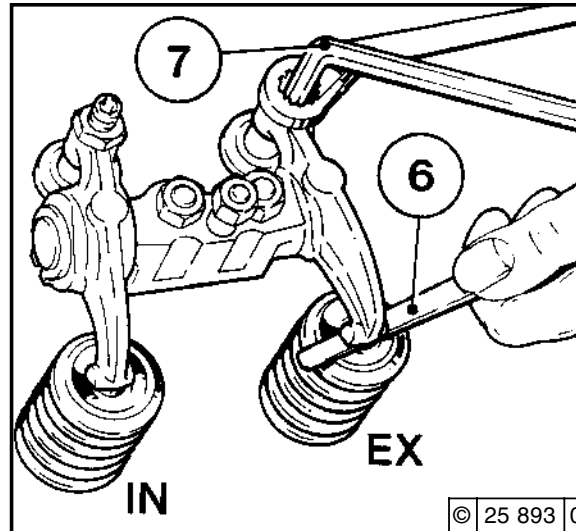
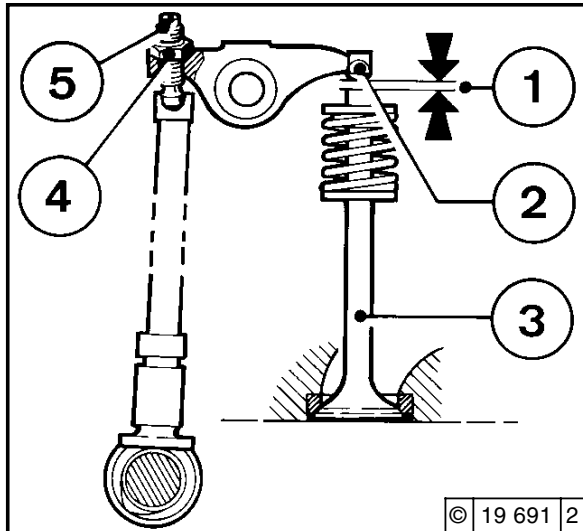
Check and change belts only with the engine off.
Reinstall V-belt guard, if necessary. Retension V-belt after it has ran for 15 minutes.

Service and Maintenance

6.6 Adjustments

6

6.6.1 Check valve clearance, adjust if necessary



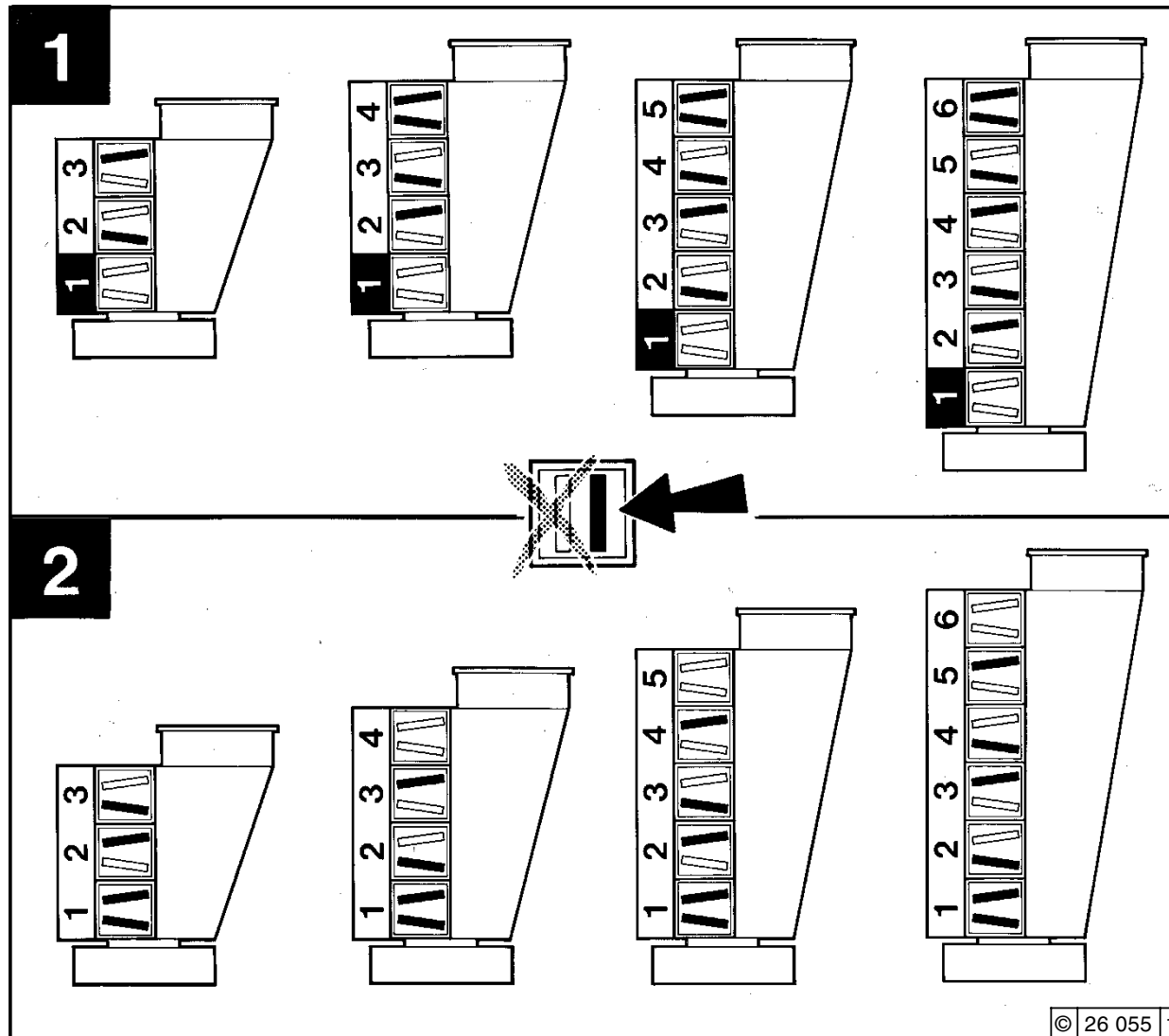
- Remove the cylinder head cover.
 - Position crankshaft as per schematic, see 6.6.1.1.
 - Before adjusting valve clearance, allow engine to cool down for at least 30 minutes. The oil temperature should be below 80 °C.
 - Check valve clearance 1 between rocker arm / tappet contact face 2 and valve stem 3 with feeler gauge 6 (there should be only slight resistance when feeler blade is inserted).
- For permissible valve clearance, see 9.1.

- Adjust valve clearance if necessary:
 - Release locknut 4.
 - Use allen key 7 to turn setscrew 5 so that the correct clearance is attained after locknut 4 has been tightened.
- Check and adjust valve clearance on all cylinders.
- Reinstall cylinder head cover with new gasket if necessary.

For high output settings, the engines are fitted with an additional oil nozzle to lubricate bearings. If necessary, readjustment may only be carried out in an authorised specialist workshop!

6.6 Adjustments

Service and Maintenance

6.6.1.1 Schematic for
Valve Clearance Adjustments● **Crankshaft Position 1:**

Turn crankshaft until both valves in cylinder 1 overlap (exhaust valve about to close, inlet valve about to open). Adjust clearance of valves **marked in black** on schematic. Mark respective rocker arm with chalk to show that adjustment has been carried out.

● **Crankshaft Position 2:**

Turn crankshaft one full revolution (360°). Adjust clearance of valves **marked in black** on schematic.

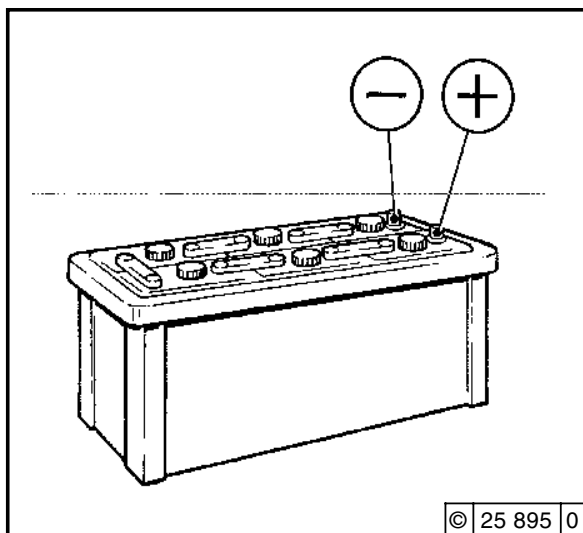
Service and Maintenance

6.7 Accessories

6

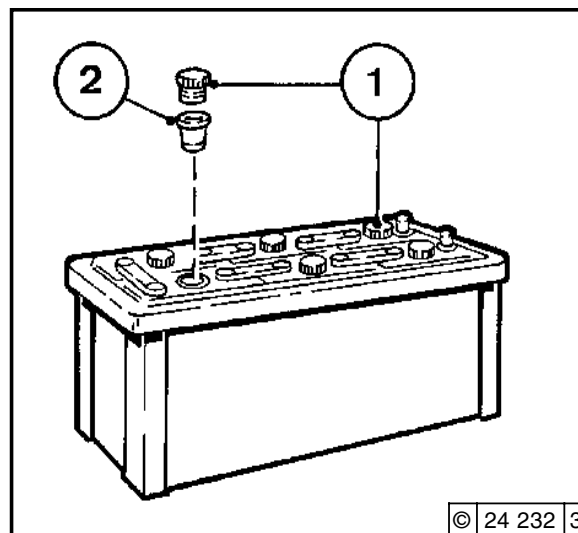
6.7.1 Battery

6.7.1.1 Checking battery and cable connectors



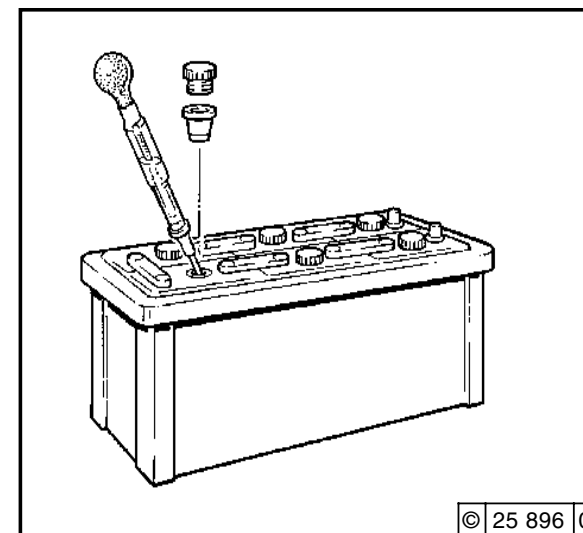
- Keep battery clean and dry.
- Undo dirty clamps.
- Clean terminal posts (+ and -) and clamps of the battery, and grease with acid-free and acid-resistant grease.
- When reassembling, ensure that clamps make good contact. Tighten clamp bolts hand-tight.

6.7.1.2 Check Electrolyte Level



- Remove sealing caps 1.
- If testers 2 are present: Electrolyte level should reach the base of these.
- Without testers:
The electrolyte level should be 10-15 mm above the top of the plates.
- If necessary, top up with distilled water.
- Screw sealing caps back in.

6.7.1.3 Check electrolyte density



- Measure the electrolyte density of individual cells with a commercial hydrometer.

The hydrometer reading (see table on following page) indicates the battery's state of charge.

During measurement, the temperature of the electrolyte should preferably be +20 °C.

in [kg/ l]		in [°Bé (Baumé scale)*]		Charge status
Normal	Tropical	Normal	Tropical	
1,28	1,23	32	27	well charged
1,20	1,12	24	16	semi-charged, re-charge
1,12	1,08	16	11	discharged, immediately charge

* Measurement of electrolyte density in ° Bé (Baumé-scale) is out of date and rarely used today.



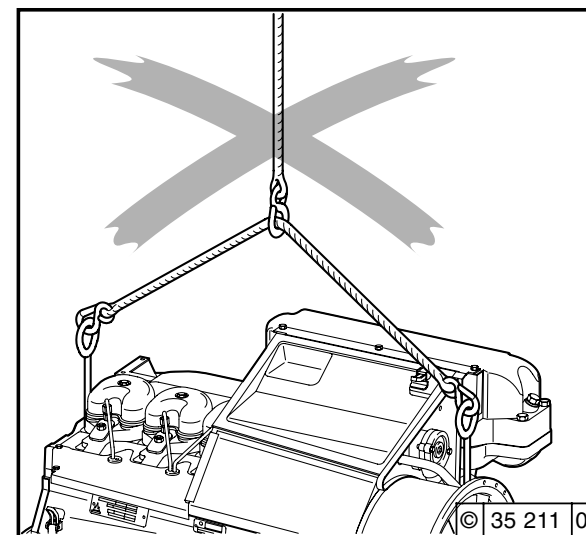
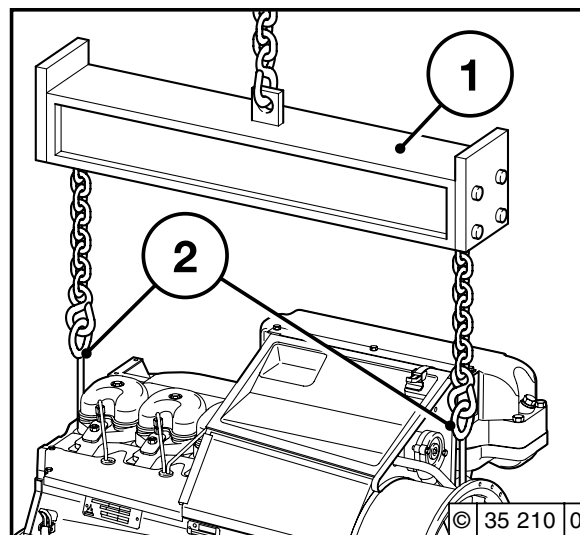
The gases emitted by the battery are explosive! Keep sparks and naked flames away from the battery! Do not allow battery acid to come into contact with skin or clothing! Wear protective goggles! Do not rest tools on the battery!

6.7.2 Rotary Current Alternator

6.7.3 Transportation Shackles

Notes on the three-phase system:

- Never disconnect the cables between battery, alternator and regulator while the engine is **running**.
- If, however, it is necessary to start and operate the engine without the battery, disconnect the regulator from the alternator before starting.
- Be sure not to confuse the battery terminals.
- Replace defective charge pilot lamp bulb immediately.
- When washing the engine, cover up the alternator and regulator.
- The habit of touching a lead against the frame to check whether it is live must under no circumstances be exercised with three-phase electrical systems.
- In case of electric welding, connect the ground terminal on the welder directly to the piece being welded.



- Always use proper lifting tackle 1 when transporting the engine.
- After transportation and before commissioning of the engine: Remove attachment eyes 2.



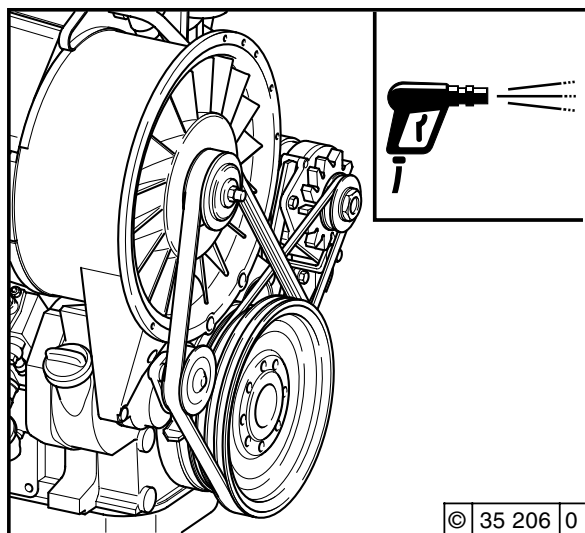
Use only the correct lifting gear!

6.8. Engine Cleaning

Service and Maintenance

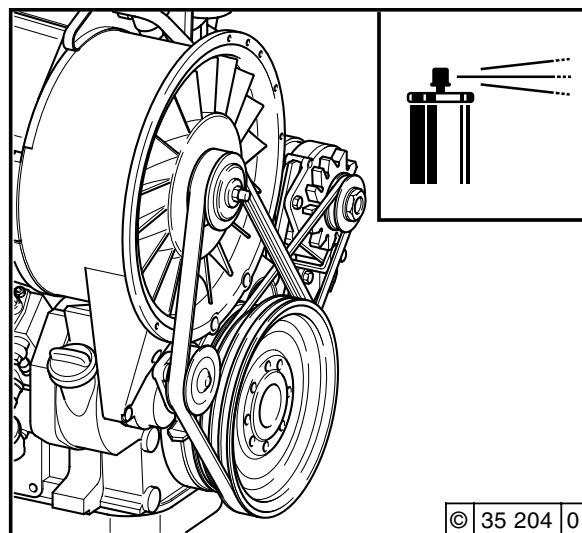
6.8.1 Engine cleaning

Using compressed air



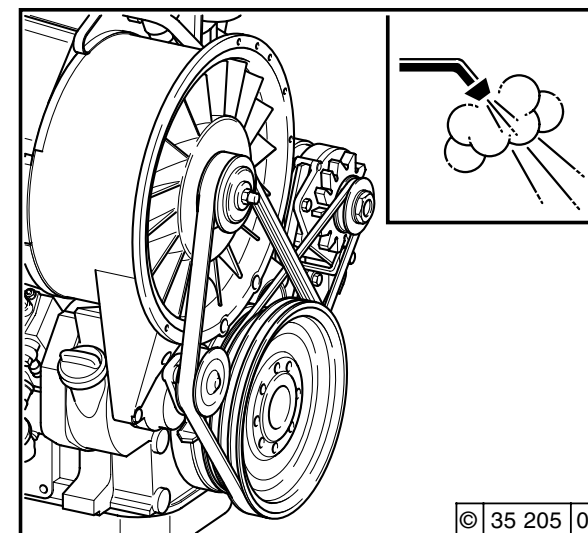
- Switch off the engine.
- Remove engine covers and cooling air hood. Replace them after cleaning and before the test run.
- Cover electrical / electronic components / connections (e.g. generator, starter, governor, solenoid).
- Blow air through the engine, taking particular care not to damage the cooler and cooling fins (begin to blow through air from the exhaust side). Remove the dirt which has blown into the interior space.

Using cold-cleaning compound

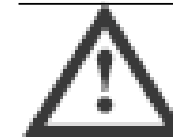


- Switch off the engine.
- Remove engine covers and cooling air hood. Replace them after cleaning and before the test run.
- Cover electrical / electronic components / connections (e.g. generator, starter, governor, solenoid).
- Spray the engine with the commercial cold-cleaning compound and allow to react for approx. 10 mins.
- Spray clean the engine with a strong water jet, repeat if necessary.
- Allow the engine to run warm so that the remaining water evaporates.

Using high pressure device

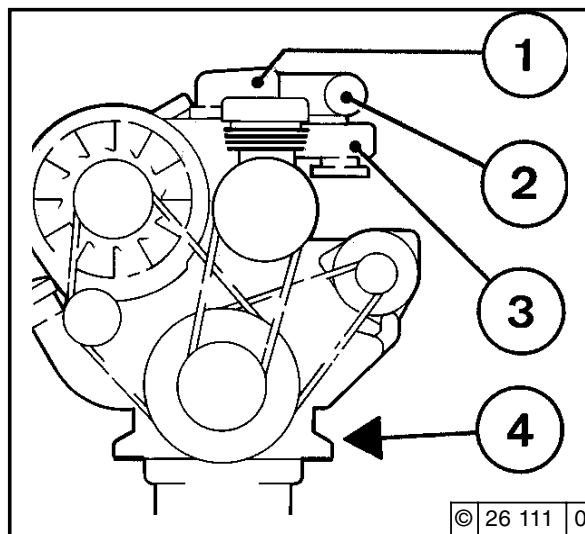


- Switch off the engine.
- Remove engine covers and cooling air hood. Replace them after cleaning and before the test run.
- Cover electrical / electronic components / connections (e.g. generator, starter, governor, solenoid).
- Clean the engine with a steam jet (max. spray pressure of 60 bar, max. steam temperature of 90°C).
- Allow the engine to run warm so that the remaining water evaporates.



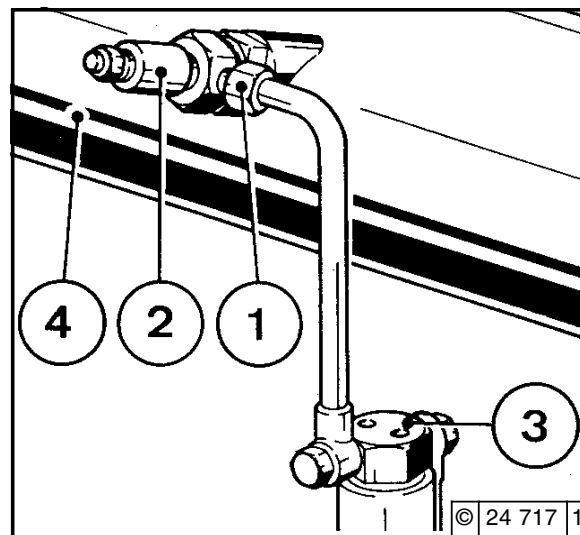
Clean the engine only when the engine is switched off!

6.9.1 Checkfastenings

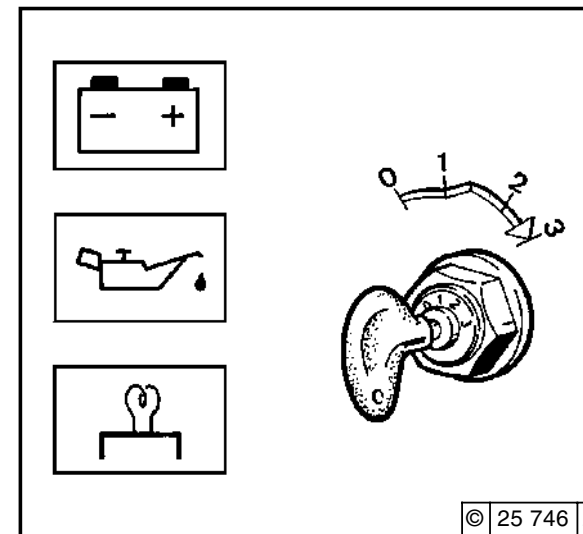


- Cylinder head cover 1
- Air intake manifold 2
- Connection sockets 3
- Exhaust line 4
- Engine mounts 4

6.9.2 Checking the function of the glow plugs

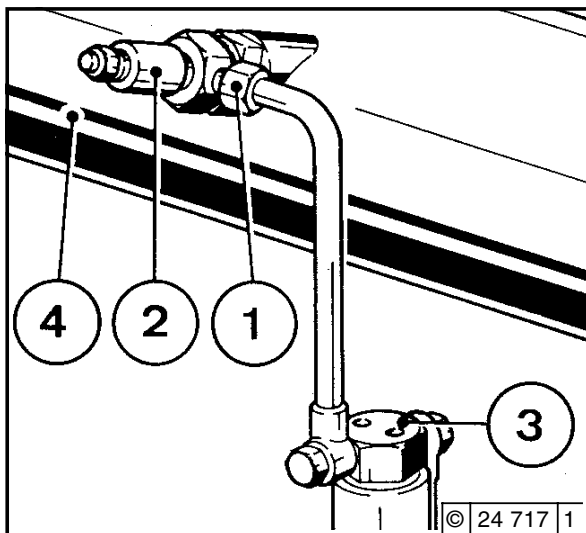


- With perfect function, the air-intake pipe 4 warms up near the glow lamps 2 from pre-glowing.

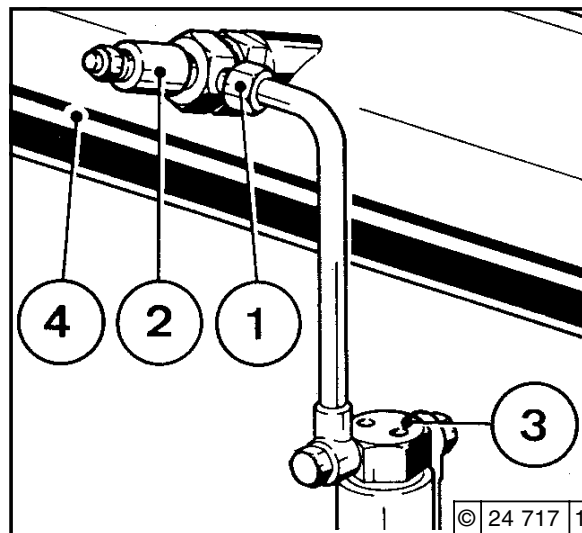


Test step 1

- Place speed control lever or shut-off lever in "stop" position.
- Insert key
 - Position 0 = no operating voltage
- Key clockwise
 - Position 1 = operating voltage
 - Pilot lights illuminate
- Push key in and turn further clockwise against spring pressure.
 - Position 2 = Preheat, hold for approx. 1 minute.
 - Preheat lamp comes on
- Otherwise the glow lamps are defective or the transmission line interrupted.

**Test step 2**

- Loosen screw 1.
- Turn engine over with starter, key in switching position 3.
- Fuel must be present on the loosened pipe connection. Otherwise, the system and solenoid valve should be checked by a specialist!

**Test step 3**

- Loosen screw 1.
- Remove glow lamps 2
- Turn engine over with starter, key in switching position 3.
- Fuel must be present on the glow lamps 2, or replace glow lamps 2 if necessary.
- When fitting glow lamps 2, use DEUTZ DW 47 sealants.
- Reinstall glow lamps to fuel line.



Keep away from moving parts!
Collect any escaping fuel and dispose of this in an environmentally-friendly manner.

APPENDIX A

Faults, Causes and Remedies

7.1 Fault Table

APPENDIX A

Faults, Causes and Remedies

7.1 Fault Table

7

Faults										Measures	
Engine does not start or is difficult to start										Check	P
Engine starts, but runs irregularly or fails										Adjust	E
Engine overheats, temperature warning system responds										Replace	W
Engine output is deficient										Clean	R
Engine does not run on all cylinders										Top up	A
Engine oil pressure is non-existent or excessively low										Reduce	S
Engine oil consumption excessive											
Engine smokes - blue											
- white											
- black											
Cause										Section	
●										Not declutched (where possible)	Engine Operation P
●								●		Below starting limit temperature	P
●			●							Engine shut-off lever still in stop position (shut-off magnet defective)	P
		●			●					Oil level too low	A
		●	●			●	●			Oil level too high	S
					●	●	●			Excessive inclination of engine	P/E
						●	●			Engine runs mainly with low load	P
●		●	●			●	●		●	Air cleaner clogged / turbocharger defective	Combustion air W
		●	●						●	Air cleaner service switch / indicator defective	P/W
			●							CPD defective (connection line leaks) only with turbocharged engines	P/W
		●	●						●	Exhaust gas backpressure too high	P
			●						●	Charge air line leaking, only with supercharged engines	P/E
		●								Cooling fins soiled	Cooling system P/R
		●	●						●	Intercooler soiled	P/R
		●			●					Oil cooler soiled on the air and/or the oil side	P/R
		●								Cooling fan or exhaust tension defective, torn or loose V-belt	P/W
		●								Cooling air temperature rise / heating short circuit	P
		●								Cooling air guide loose, torn or missing	P

APPENDIX A

7.1 Fault Table

Faults, Causes and Remedies

7

Faults										Measures		
Engine does not start or is difficult to start										Check	P	
Engine starts, but runs irregularly or fails										Adjust	E	
Engine overheats, temperature warning system responds										Replace	W	
Engine output is deficient										Clean	R	
Engine does not run on all cylinders										Top up	A	
Engine oil pressure is non-existent or excessively low										Reduce	S	
Engine oil consumption excessive												
Engine smokes - blue												
- white												
- black												
Cause										Section		
●										Battery defective or discharged	Electrics	P
●										Cable connections, starter, electrical circuit loose or oxidised		P
●										Starter defective or pinion does not engage		P
					●					Oil pressure switch / gauge defective		P/W
●	●	●	●	●				●	●	Incorrect valve clearance	Engine	P/E
●	●		●	●						Injection line leaks		P/R
		●								Ventilation line blocked		P/R
●	●							●		Glowplugs		P/W
●	●	●	●	●				●	●	Injection valve defective		P/W
●	●		●	●						Air in the fuel system		P/W
●	●		●	●						Fuel filter / fuel pre-cleaner soiled		P/R/W
		●				●				Oil filter defective		W
●					●	●				Incorrect engine lube oil SAE class or quality		W
●	●		●	●				●	●	Compression too low		P
							●			Oil in combustion chamber		P/R

Engine Preservation

8.1 Preservation

8

8.1 Preservation

If the engine is to remain idle for an extended period of time, it is necessary to take protective measures to prevent the formation of corrosion. The preservative measures described here will protect the engine for up to approx. 6 months. The procedure will have to be reversed before the engine is recommissioned

- Anti-corrosion oils to specification:
 - MIL-L 21260B
 - TL 9150-037/2
 - Nato Code C 640 / 642
- Recommended cleaning agent to remove preservatives:
 - Petroleum benzine (hazardous materials class A3)

8.1.1 Preserve engine

- Clean engine (with cold cleansing agent if preferred) using high pressure equipment (see 6.8.1).
- Run engine until warm, then turn off.
- Drain engine oil, (see 6.1.2), and fill with anti-corrosion oil.
- If necessary, clean oil bath cleaner (see 6.4.3), and fill with anti-corrosion oil.
- Drain fuel tank.
- Make up a mixture of 90 % diesel fuel and 10 % anti-corrosion oil, and refill fuel tank.
- Allow the engine to run for approx. 10 mins.
- Switch off the engine.
- Turn engine over manually several times to preserve the cylinders and combustion chamber.
When turning over with starter, set shut-off lever to stop position.
- Remove V-belts and store wrapped, dry and recumbent.
- Spray grooves on V-belt pulleys with anti-corrosion spray.
- Close off intake ports and exhaust ports, possibly with plugs.

8.1.2 Remove engine preservation

- Remove anti-corrosion agent from grooves in V-belt pulleys.
- Install V-belt, retension after brief operation if necessary (see 6.5).
- Remove covers from intake port and exhaust ports.
- Commission engine.

9.1 Engine Specifications and Settings

9.2 Screw Tightening Torques

9.3 Tools

Technical Specification

9.1 Engine Specifications and Settings

9

Model		F3L 914	F4L 914	F5L 914	F6L 914
Number of cylinders		3	4	5	6
Cylinder arrangement		vertical in line			
Bore	[mm]	102			
Stroke	[mm]	132			
Total displacement	[cm ³]	3236	4314	5393	6472
Compression ratio	[ε]	20			
Working cycle		4-stroke naturally aspirated diesel engine			
Combustion system		Direct injection			
Direction of rotation seen on flywheel		counter-clockwise			
Weight including cooling system to DIN 70020-A without starter or alternator	[approx. kg]	270 ⁵⁾	300 ⁵⁾	380 ⁵⁾	410 ⁵⁾
Engine output	[kW]	1)			
Speed	[rpm]	1)			
Lubrication		Pressure lubrication			
SAE oil		15W 40			
Oil temperature in oil pan	[°C]	135			
Min. oil pressure when warm (120 °C) and low idle	[bar]	0,4 ⁴⁾			
Oil plate filling quantity without filter	[approx. litres]	9,0 ³⁾	12,0 ³⁾	13,5 ³⁾	14,5 ³⁾
Oil plate filling quantity with filter	[approx. litres]	9,6 ³⁾	13,0 ³⁾	15,0 ³⁾	16,0 ³⁾
Valve clearance with cold engine	[mm]	Inlet 0,15 + 0,05 / exhaust 0,15 + 0,05			
Injector opening pressure	[bar]	200 + 10			
Start of feed	[°KW of TDC]	1)			
Firing order of the engine		1–2–3	1–3–4–2	1–2–4–5–3	1–5–3–6–2–4
V-Belt tension:		Pre-tension / re-tension ²⁾			
Alternator fan	[N]	450 / 300 ± 20			
Compressor	[N]	550 / 400 ± 20			

1) Engine output, speed, start of delivery are stamped on engine rating plate, etc., (see also 2.1).

2) Re-tension 15 minutes after the engine has been operated under load.

3) Approx. values may vary depending on version. The upper oil dipstick mark is always authoritative.

4) Values for engines without engine oil heating.

5) Approx. values may vary depending on version.

9.1 Engine Specifications and Settings

Technical Specification

914/C/CT Model	BF3L 914	BF4L 914	BF6L 914	BF6L 914 C
Number of cylinders	3	4	6	6
Cylinder arrangement	vertical in line			
Bore[mm]	102			
Stroke[mm]	132			
Total displacement [cm ³]	3236	4314	6472	6472
Compression ratio [ε]	18			
Working cycle	4-stroke turbocharged diesel engine			
Combustion system	Direct injection			
Direction of rotation seen on flywheel	counter-clockwise			
Weight including cooling system to DIN 70020-A without starter or alternator [approx. kg]	320 ⁵⁾	360 ⁵⁾	485 ⁵⁾	510 ⁵⁾
Engine output [kW]	1)			
Speed [rpm]	1)			
Lubrication	Pressure lubrication			
SAE oil	15W 40			
Oil temperature in oil pan [°C]	135			
Min. oil pressure when warm (120 °C) and low idle [bar]	0,5 ⁴⁾			
Oil plate filling quantity without filter [approx. litres]	9 ³⁾	12 ³⁾	16,0 ³⁾	16,0 ³⁾
Oil plate filling quantity with filter [approx. litres]	9,6 ³⁾	13 ³⁾	17,5 ³⁾	17,5 ³⁾
Valve clearance with cold engine [mm]	Inlet 0,15 + 0,05 / exhaust 0,15 + 0,05			
Injector opening pressure [bar]	200 + 10			
Start of feed [°KW of TDC]	1)			
Firing order of the engine	1-2-3	1-3-4-2	1-5-3-6-2-4	1-5-3-6-2-4
V-Belt tension: Pretension / Retension	Pretension / Retension ²⁾			
Alternator fan [N]	400 / 250 ± 20			
Compressor [N]	500 / 350 ± 20			

1) Engine output, speed, start of delivery are stamped on engine rating plate, etc., (see also 2.1).

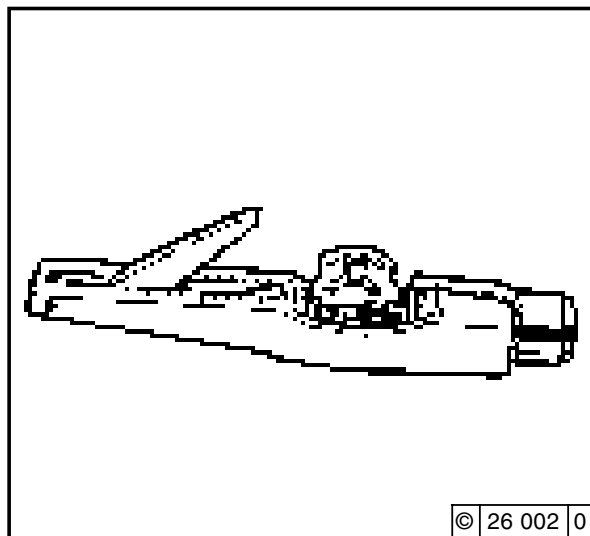
2) Re-tension 15 minutes after the engine has been operated under load.

3) Approx. values may vary depending on version. The upper oil dipstick mark is always authoritative.

4) Values for engines without engine oil heating.

5) Approx. values may vary depending on version.

Installation	Pretension [Nm]	Retension				Total	Comments
		1 st position	2 nd position	3 rd position	4 th position		
Securing the alternator	20	180°	–	–	–	180°	M10 x 180
	30	180°	–	–	–	180°	M14 x 230
Cylinder head cover	–	–	–	–	–	12 ± 1,2 Nm	–
Valve clearance adjusting screw Foot	–	–	–	–	–	22 ± 2 Nm	–
	30	60°	15°	–	–	75°	M14 x 100
	30	60°	45°	–	–	105°	M14 x 110
	30	60°	45°	–	–	105°	M14 x 125
Intake manifold	–	–	–	–	–	21 ± 2 Nm	–
Exhaust manifold	–	–	–	–	–	40 ± 4 Nm	–
Oil drain screw	–	–	–	–	–	150 ± 10 Nm	M30 x 1,5
Oil drain screw	–	–	–	–	–	80 ± 10 Nm	M22 x 1,5
Injection valve attachment	–	–	–	–	–	25–30 Nm	–

V-belt tension gauge

The V-belt tension gauge can be obtained under order number 8115 from:

WILBÄR
Postfach 14 05 80
D-42826 Remscheid

APPENDIX B

LOFA EP250 Operation and Troubleshooting

Introduction

This document provides general information on LOFA Industries EP250 control systems operation and troubleshooting. EP250 control systems are a very flexible platform for diesel engine control, monitoring, and protection, featuring LOFA's powerful First Fault Diagnostics (FFD). After pinpointing the initial failure, FFD stores it in memory and alerts the end user via a single bright LED. FFD monitors battery charge, low oil pressure, high temperature, overspeed and up to three additional contact closure inputs. The field configurable, expandable microprocessor-based solid-state design uses high-power semiconductors instead of outdated electromechanical relays to ensure reliable high-current switching.

The EP250 features LOFA's new modular Function Enhancement Packs (FEP). The plug-and-play FEP modules allow various feature upgrades to be easily added to the standard platform. FEPs include:

- Diagnostic Program Gauge (DPG)
- Auto-Start with Real-time Clock
- Data Logging
- Closed Loop Speed Control
- Precision Actuator Control
- Custom OEM Solutions

The Diagnostic Program Gauge (DPG) features a backlit LCD display with three push buttons all in a compact 2 inch gauge. The LCD is clearly readable in both bright sunlight as well as total darkness. The DPG provides a complete user interface for other Function Enhancement Packs and allows each system to be field configured to suit the customer's unique requirements. After configuring, the DPG can be removed in cost-sensitive applications.

Some of the EP250 configurable features include:

- Automatic preheat duration
- Afterglow duration
- Failure indication with shutdown or indication only
- Over-speed shutdown
- Normally open or normally closed shutdown switches

All standard panels include feature a 12 inch wiring harness terminating into a sealed weather proof plug. This robust universal wiring connection performs well in harsh environments and allows interchanging a number of different panels and harnesses. This design allows for simplified installation as well as a flexible means to incorporate custom plug-and-play engine wiring harnesses and standard harness extension

Note

The engine harness is not included with the panel.

A number of standard engine harnesses are available or
LOFA can develop a custom harness for you exact needs.

Generic harnesses in various lengths are available for field customization.

Warning

When replacement parts are required, LOFA Industries recommends using replacement parts supplied by LOFA or parts with equivalent specifications.

Failure to heed this warning can lead to premature failure,
product damage, personal injury or death.

Important Safety Information

The warnings in this publication are not all inclusive.

LOFA Industries cannot anticipate every potential hazard.

Appropriate safety rules and precautions should be followed with any
tool, work method or operating procedure.

Improper procedures, tools and materials may cause
damage or make the equipment unsafe to operate.

Only persons with appropriate training, skills and tools
should perform these functions.

Improper operation, maintenance or repair of this product can be
dangerous and may result in injury or death.

Do not operate or perform any maintenance or repair on this product until all operation,
maintenance and repair information is read and understood.

The information, specifications, and illustrations in this publication are based on information
available at the time of publication.

All items are subject to change at any time without notice.

Operation

Turning the control system key to the run position starts a self-test which causes all LEDs to illuminate once, activates the alarm output for one second and enables the fuel run/stop solenoid output. After self-test, the LEDs indicate the state of the inputs they monitor. The normal indications are battery charge and oil pressure on most applications. If these LEDs are not illuminated at this time it may indicate the inputs are not properly connected.

The Preheat LED is illuminated when the key switch is turned to the run position if automatic preheat is configured or if an external preheat control is connected (See Preheat Options). Preheat time varies from application to application. After waiting for the Preheat LED to extinguish, the engine is cranked by turning and holding the key switch in the start position until the engine starts. The key switch is spring loaded to return automatically to the run position when released. The Preheat LED is illuminated during afterglow if enabled.

Note

The key switch is equipped with a mechanical start locking device.
An attempt to re-crank the engine can only be made by turning the key switch to the off position to reset the start locking mechanism.

If the engine is not started within 10 seconds of turning on the system, the fuel run/stop solenoid output is turned off to prevent battery discharge when the key switch is left in the run position. The fuel run/stop solenoid output is turned off after 10 seconds even if preheating. As soon as the key switch is turned to the start position the solenoid output is enabled. The afterglow cycle begins when the key switch returns to the run position.

Note

If conditions do not warrant preheat, the engine may be started by turning the key to the start position without waiting for the preheat time to expire.

Control system instrument power, including the hourmeter and voltmeter, is provided by the fuel run/stop solenoid output. If the instruments do not power up when the key is turned to the run position, this indicates a problem with the solenoid circuit (see Troubleshooting).

After the engine starts, the control system electronics ignore all shutdown conditions for the first 10 seconds. This delay eliminates the requirement to hold a by-pass override button during starting and allows the system conditions such as oil pressure to normalize. The 10 second timer starts when the key switch returns to the run position.

Note

Starter input is required for correct system operation. If the starter motor input is not activated (connected to battery positive) and the engine is started through another means (i.e. air starter) the engine will shutdown 10 seconds after the key switch is turned to the run position.

APPENDIX B

LOFA EP250 Operation and Troubleshooting

To prevent unintentional engine shutdowns caused by intermittent conditions (i.e., pressure spikes, coolant movement) the control system requires a constant 1 second fault input to cause engine shutdown.

Warning

When used in combination with mechanical float type switches engine vibrations may prevent constant contact closure.
The control system can be configured to shutdown with no delay.

See the *EP250 Configuration Guide* for detailed preheat control instructions.

The control system has the ability to shut down the engine for over speed. Over speed will be indicated via a blinking **Battery Charge** LED. If the control system is equipped with the DPG, the display will also indicate over speed shutdown. The control system senses RPM either by the frequency terminal of the alternator, proximity switch or magnetic pick-up.

Preheat Options

Preheat Output

Preheat is a 1A output for control of an external power relay with predetermined preheat and afterglow times. A relay should be selected with appropriate amperage capacity for the installed cold starting aid (glowplug, intake air heater, etc.). Applications using multiple cold starting aids may require multiple relays. Optional or additional components may allow preheat time to be modified by sensing ambient temperature. Depending on specific configuration, this output may provide either high side (battery positive) or low side (ground) control.

Note

Consult engine documentation when selecting cold starting aid, power relay and heating specifications.

Preheat Indication Input

With this option, the preheat LED provides indication for an external preheat control system. Depending on specific controls and configuration, this input can be configured to accept either high side (battery positive) or low side (ground) control.

Indicators



Battery LED (Red)

A solidly illuminated Battery LED indicates a battery charge failure. A battery charge failure may be caused by a faulty alternator, broken drive belt or the alternator not excited. A battery voltage reading of approximately 14 volts on a 12 volt system (28 volts on a 24 volt system) while the engine is running indicates the battery is charging properly. Irregular blinking of the Battery LED may indicate a failing charge circuit. The system can be configured for battery charge failure to indicate only.

Overspeed Indication

A regularly blinking Battery LED indicates the configured overspeed RPM has been exceeded. The overspeed RPM can be verified, changed or disabled (see the *EP250 Configuration Manual* for details).



Oil Pressure LED (Red)

A solidly illuminated Oil Pressure LED indicates low oil pressure failure. The control system typically senses low oil pressure from a ground contact switch on the engine. When a sender/switch combination is used on the engine, the marking **WK** generally indicates the switch terminal. This input typically expects a normally closed switch (ground contact when oil pressure is low). A defective switch or shorting the shutdown input to ground can cause low pressure fault indication. Additionally, when using sender/switch combinations, swapping the **WK** and **G** terminal can cause unintended shutdowns. The system can be configured for oil pressure failure to indicate only.

Warning

Low oil pressure is not an indication of low oil level.

For best possible protection LOFA recommends using
our solid-state oil level shutdown switch.

Note

Most shutdown switches are grounded through the switch body.
Do not use insulating sealant (i.e. Teflon tape) when installing switches.



Temperature LED (Red)

A solidly illuminated Temperature LED indicates high engine temperature failure. The control system typically senses high temperature from a ground contact switch on the engine. When a sender/switch combination is used on the engine, the marking **WK** or **W** generally indicates the switch terminal. This input typically expects a normally open switch (ground contact when engine temperature is too high). A defective switch or shorting the shutdown input to ground can cause over temperature fault indication. Additionally, when using sender/switch combinations, swapping the **WK** or **W** and **G** terminal can cause unintended shutdowns. The system can be configured for temperature failure to indicate only.

Warning

If the temperature switch is not in contact with coolant due to
coolant loss the engine is not protected from overheating.

For best possible protection, LOFA recommends using
our solid-state coolant level shutdown switch.

Note

Most shutdown switches are grounded through the switch body.
Do not use insulating sealant (i.e. Teflon tape) when installing switches.

Some thermostat housings are composites and do not provide ground for the switch.



AUX 1 LED (Red)

A solidly illuminated AUX 1 LED indicates auxiliary 1 failure (i.e., coolant level, oil level, belt breakage, hydraulic pressure, etc.). The control system typically senses failure using a ground contact switch. Auxiliary inputs are equipment specific and determined by the equipment manufacturer. A defective switch or shorting

the shutdown input to ground can cause fault indications. The system can be configured for auxiliary 1 failure to indicate only.

A blinking AUX 1 LED indicates SW input failure. The control system typically senses failure using a ground contact switch. The SW input is equipment specific and determined by the equipment manufacturer. A defective switch or shorting the shutdown input to ground can cause fault indications.



AUX 2 LED (Red)

A solidly illuminated AUX 2 LED indicates auxiliary 2 failure (i.e., air flow restriction, fuel level, etc.) but by default does not cause a shutdown. The control system typically senses failure using a ground contact switch. Auxiliary inputs are equipment specific and determined by the equipment manufacturer. A defective switch or shorting the shutdown input to ground can cause fault indications. The system can be configured for auxiliary 2 failure to indicate only.



Preheat LED (Red)

A solidly illuminated Preheat LED is the system preheat indication. When the LED extinguishes the preheat period is complete and the engine may be cranked. The LED illuminates again to indicate afterglow.

Gauges

Voltmeter

The voltmeter is connected to the fuel run/stop solenoid output. If the voltmeter does not indicate in the run position, this indicates a problem with the solenoid circuit. A battery voltage reading of approximately 14 volts on a 12 volt system (28 volts on a 24 volt system) while the engine is running indicates the battery is charging properly.

Tachometer

The tachometer indicates engine RPM using a frequency signal derived from the engine. This signal may be provided by an alternator frequency tap, proximity switch. An optional amplifier/divider can be added for use with a magnetic pickup.

Note

If the alternator is not excited (not charging),
no frequency is generated and the tachometer will indicate 0 RPM.

The tachometer is factory calibrated to indicate correctly when the panel is preconfiguring or field calibrated with a Diagnostic Programming Gauge (DPG). The tachometer can be calibrated using standard procedures if the configuration is not performed (see ***Tachometer Calibration Instructions*** for details).

Oil Pressure Gauge

The gauge measures oil pressure with a resistance sender on the engine referenced to ground. When a sender/switch combination is used on the engine, the marking **G** generally indicates the gauge terminal. The gauge expects a low resistance for low pressure and a higher resistance for higher pressure. If the gauge is not connected to the sender, the gauge will read full scale (pegged). A defective sender or shorting the gauge input to ground will cause the gauge to read 0 pressure. When using sender/switch combinations, swapping the **WK** and **G** terminal prevents the gauge from working and may cause unintended shutdowns.

Warning

Low oil pressure is an indication of engine wear,
not an accurate indication of low oil level.

Note

Senders and gauges must be matched to indicate correctly.

Most senders are grounded through the sender body.
Do not use insulating sealant (i.e. Teflon tape) when installing senders.

Temperature Gauge

The gauge measures engine temperature with a resistance sender on the engine referenced to ground. When a sender/switch combination is used on the engine, the marking **G** generally indicates the gauge terminal. The gauge expects a high resistance for low temperatures and a lower resistance for higher temperatures. If the gauge is not connected to the sender, the gauge will read 0. A defective sender or shorting the gauge input to ground will cause the gauge to read full scale (pegged). When using sender/switch combinations, swapping the **WK** and **G** terminal prevents the gauge from working and may cause unintended shutdowns.

Warning

If the temperature sensor is not in contact with coolant due to coolant loss
the gauge will not accurately indicate engine temperature.

Note

Senders and gauges must be matched to indicate correctly.

Most senders are grounded through the sender body.
Do not use insulating sealant (i.e. Teflon tape) when installing senders.

Some thermostat housings are composites and do not provide ground for the sender.

Hourmeter

The hourmeter is connected to the fuel run/stop solenoid output. If the hourmeter does not count in the run position, this may indicate a faulty hourmeter or a problem with the solenoid circuit. If the engine shutdowns or is not started within 10 seconds the hourmeter stops counting.

Additional Gauges

Additional gauges can be added by removing blind covers and installing the gauge. Power connections are provided with the standard configuration.

Harness

Sealed Connectors

The provided sealed weather proof plug includes a grey locking device which must be released to separate the connectors. Press the tab on the connector housing to release the connectors.

Warning

LOFA does not recommend using dielectric grease or sealant with sealed connectors.
These chemicals may cause seal damage and allow water entry.

Use LOFA provided cavity plugs to seal the connector if wires are removed.

Unsealed Connectors

For unsealed connectors exposed to the elements, LOFA recommends using dielectric grease to protect contacts.

Warning

LOFA does not recommend using sealant with unsealed connectors.
Sealant traps moisture in the connector and encourages corrosion.

Harness Routing

The minimum routing of radius of the wiring harnesses should be at least two times the diameter of the wiring harness. Bends should be avoided within 1 inch (25 mm) of any connector in order to avoid seal distortion allowing moisture to enter the connector.

Note

For harness length in excess of 10 ft a relay must be added to the start solenoid circuit.

LOFA offers starter relay kits for mounting near the engine.

Battery Circuit Requirements

Battery Positive Connection

The electronic control system operates on either a 12 VDC or 24 VDC electrical systems. The unswitched battery positive connection to the control system is made at the weather proof connector. The control system provides switched positive battery protected by a 15 Amp fuse (12 V or 24 V system).

Protection for the unswitched battery positive circuit is dependent on specific equipment configuration. The overload protection should not exceed 125% of the sum of all output currents plus 5 Amps for the control system. Powering the control system through dedicated circuits with appropriate overload protection reduces the possibility of system damage.

Circuit breakers are preferred over in-line fuses for circuit protection. Over current protection devices should ideally be located in a central location. If automatic reset circuit breakers are used, consideration of the environment of the breaker is critical and may affect the trip point. The trip point of some circuit breakers can be significantly reduced below the rated trip point if the circuit breaker is exposed to high temperatures.

Warning

Disconnecting the battery while the engine is running
may damage electrical components.

When using a battery disconnect switch, LOFA recommends using a
2 pole switch to disconnect both the battery and alternator output.

Battery Negative Connection (Grounding)

Warning

Improper grounding can cause electrical noise, unreliable operation and may damage the control system or other components. All ground connections must be free from foreign materials, including paint, which may interfere with proper grounding.

A reliable ground must be provided for the control system.
LOFA recommends the ground connection be made directly to the battery negative.
Grounding through frame members is not recommended.

All ground paths must be capable of carrying any likely fault currents.

Do not reverse the battery polarity. Attempting to crank the engine when the polarity of the battery connections is reversed may damage the control system.

Note

A maximum of three ring terminals should be connected to a ground stud in order to ensure integrity of the ground connection. The use of more than three terminals can cause the connection to become loose.

Voltage Drop

If control system voltage drops below 6 volts for more than one tenth of a second, the control system may reset causing the self test to reactivate and the engine to shutdown after 10 seconds. Resetting the control

system is equivalent to quickly turning the key switch to off and back to run without starting the engine. Since the control system did not sense a start signal, the fuel run/stop solenoid deactivates after 10 seconds. Voltage drops can be caused by transients from external equipment, improper wire sizes, faulty wiring or nearby lightning strikes. In the absence of a *LOFA Power Box*, relays may be needed for long wire runs.

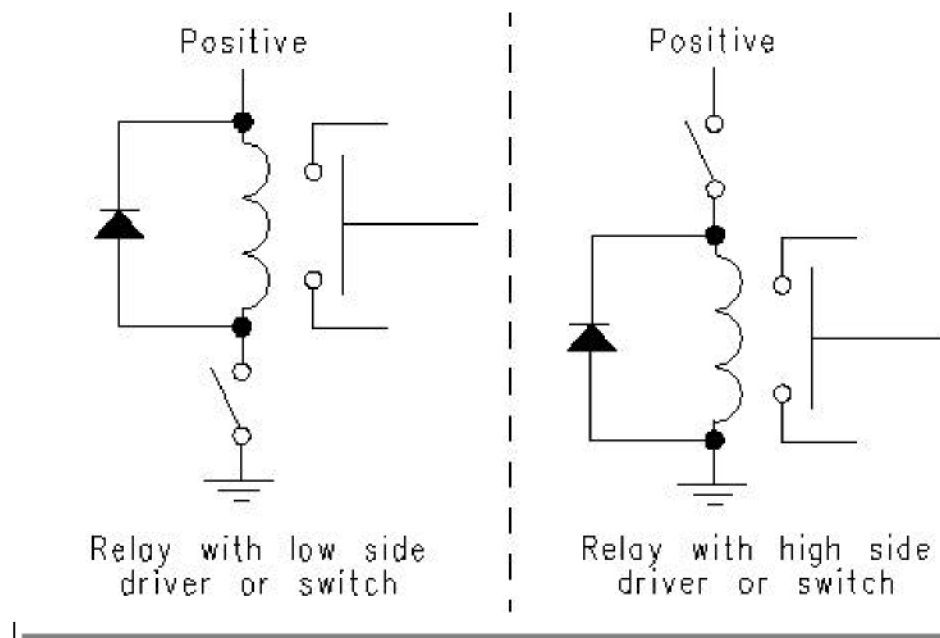
Suppression of Voltage Transients (Spikes)

Warning

The installation of voltage transient suppression at the transient source is required.

LOFA follows SAE recommended electrical environment practices.

Inductive devices such as relays, solenoids and motors generate voltage transients and noise in electrical circuits. Unsuppressed voltage transients can exceed SAE specifications and damage electronic controls.



Relays and solenoids with built-in voltage transient suppression diodes are recommended whenever possible. Refer to the illustration for proper installation of diodes when built-in voltage transient suppression is not available.

Locate inductive devices as far as possible from the components of the electronic control system. When using electric motors it may also be necessary to add isolation relays to eliminate voltage transients, noise and prevent back feed.

Note

LOFA harness assemblies typically include all required engine control suppression devices. Added equipment will require additional protection.

Welding on Equipment with Electronic Controls

Proper welding procedures are required to avoid damage to electronic controls, sensors, and associated components. The component should be removed for welding if possible.

The following procedure must be followed if the component must be welded while installed on equipment with electronic controls. This procedure will minimize the risk of component damage.

Warning

Do not ground the welder to electrical components such as the control ground or sensors.
Improper grounding can cause damage to electrical components

Clamp the ground cable from the welder to the component being welded. Place the clamp
as close as possible to the weld to reduce the possibility of damage.

1. Stop the engine. Turn the key switch to the OFF position.
2. Disconnect the negative battery cable from the battery.
3. Open any installed battery disconnect switch.
4. Unplug the control system if possible.
5. Connect the welding ground cable as close as possible to the area to be welded.
6. Protect the wiring harness from welding debris and spatter.
7. Use standard welding methods to weld the materials.

General Troubleshooting

For additional information, refer to engine manufacturer troubleshooting guide.

No response from starter motor

Possible Cause	Possible Remedy
No battery voltage to starter	Verify wiring and battery connection (power and ground)
Battery discharged	Charge or replace battery, verify alternator charging
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
No signal from control system	No power to control system (see Control System Troubleshooting below)
Defective starter solenoid	Replace starter solenoid
Defective starter motor	Replace starter motor

Engine will crank but not start

Possible Cause	Possible Remedy
Engine not getting fuel	Check fuel level, filter, fuel pump, verify no air in fuel lines
Fuel run/stop solenoid not engaged	See Fuel Solenoid Run/Stop Troubleshooting (below)
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
No preheat (cold condition)	See Preheat Troubleshooting

Engine runs for 10 seconds and shuts down

Possible Cause	Possible Remedy
Shutdown switch input active	Verify shutdown source exists, correct condition or correct faulty circuit
Battery not charging	Verify alternator charging (see Alternator not charging battery below)
Control board did not sense start signal	Engine started through alternate method (i.e., manual air start, push start, etc.)
Defective control system	See Control Panel Troubleshooting (below)

Engine runs longer than 10 seconds and shuts down

Possible Cause	Possible Remedy
Shutdown switch input active	Correct engine fault, verify shutdown switch wiring
Circuit overload protection tripped	Correct overload, keep control system from overheating (over 185° F/85° C)
Voltage transients (spikes)	Add suppressor diodes, protect from nearby lightening strikes, shield induced spikes from other equipment, add electric motor control relay
Defective control system	See Control System Troubleshooting (below)

Alternator not charging battery

Possible Cause	Possible Remedy
Broken or slipping alternator drive belt	Adjust or replace alternator drive belt
Alternator not excited	Verify excitation circuit connected, replace faulty regulator, add additional excitation resistor
Alternator output not connected	Install charge wire
Alternator not grounded	Clean or add ground connection
Alternator faulty	Replace faulty alternator

Fuel Run/Stop Solenoid Troubleshooting

Engine does not stop immediately

Possible Cause	Possible Remedy
Back feed from motor (i.e., cooling fan)	Add relay or blocking diode
Sticking solenoid linkage	Repair or replace solenoid linkage
Fuel valve without check valve	Install or repair check valve

Fuel run/stop solenoid does not engage

Possible Cause	Possible Remedy
No power to solenoid	Locate reason for lack of power and correct (Circuit overloaded? Failed suppressor diode? Faulty wiring?)
No power to solenoid pull coil	Correct faulty wiring, check pull control circuit (see Power Box Troubleshooting below)
Incorrect linkage adjustment	Adjust solenoid linkage
Faulty solenoid	Replace solenoid
Failed suppressor diode	Correct wiring (diode reversed?), replace suppressor diode
Optional e-stop engaged	Disengage e-stop

Engine not getting fuel

Possible Cause	Possible Remedy
Empty fuel tank	Fuel engine
Clogged filter	Replace filter
Air in fuel lines	Bleed fuel lines
Low fuel pressure	Replace faulty fuel pump and/or clogged filter
Faulty fuel pump	Replace fuel pump, correct wiring fault (electric fuel pump)

Preheat Troubleshooting

Engine is hard to start in cold conditions

Possible Cause	Possible Remedy
Start attempt before preheat complete	Wait for preheat time to elapse, crank as soon as time elapses
Incorrect preheat specification	Correct control system configuration, install correct control system
Heater faulty	Replace heater
Heater relay faulty	Replace relay
Preheat control not functioning	Correct wiring, correct control system configuration
Faulty control system	See Control System Troubleshooting (below)

Engine produces excessive white smoke after starting

Possible Cause	Possible Remedy
Afterglow not enabled	Reconfigure control system
Heater faulty	Replace heater
Heater relay faulty	Replace relay
Preheat control not functioning	Correct wiring, correct control system configuration
Faulty control system	See Control System Troubleshooting (below)

Control System Troubleshooting

Control system does not perform self test

Possible Cause	Possible Remedy
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
Faulty connection to battery	Correct battery connections (see Battery Circuit Requirements above)

Control system performs normal self test, engine cranks, runs and shuts down

Possible Cause	Possible Remedy
Only Battery LED illuminated	Correct battery charge failure (see Battery not charging above)
Only Oil Pressure LED Illuminated	Correct low oil pressure condition or faulty switch, correct wiring fault
Only Temperature LED Illuminated	Correct overheating condition or faulty switch, correct wiring fault
Only Aux LED Illuminated	Correct fault condition (i.e. v-belt, coolant level) or faulty switch, correct wiring fault
All normally closed shutdowns illuminate for one second (control system reset)	Add suppressor diodes, protect from nearby lightening strikes, shield induced spikes from other equipment, add electric motor control relay

Testing Shutdown Inputs

Shutdown switches signal a fault by ground contact in most systems. Shutdown operation can be verified by grounding the shutdown inputs individually. It may be necessary to remove the wire from the shutdown switch to perform this test.

Note

Most shutdown switches are grounded through the switch body.
Do not use insulating sealant (i.e. Teflon tape) when installing switches.

Some thermostat housings are composites and do not provide ground for the switch.

Revision History

Initial Release.

Rev A – 22-May-2006. Corrected typographical errors.

Rev B – 26-Oct-2006. Add symbols to *Indicators*, corrected typographical errors.

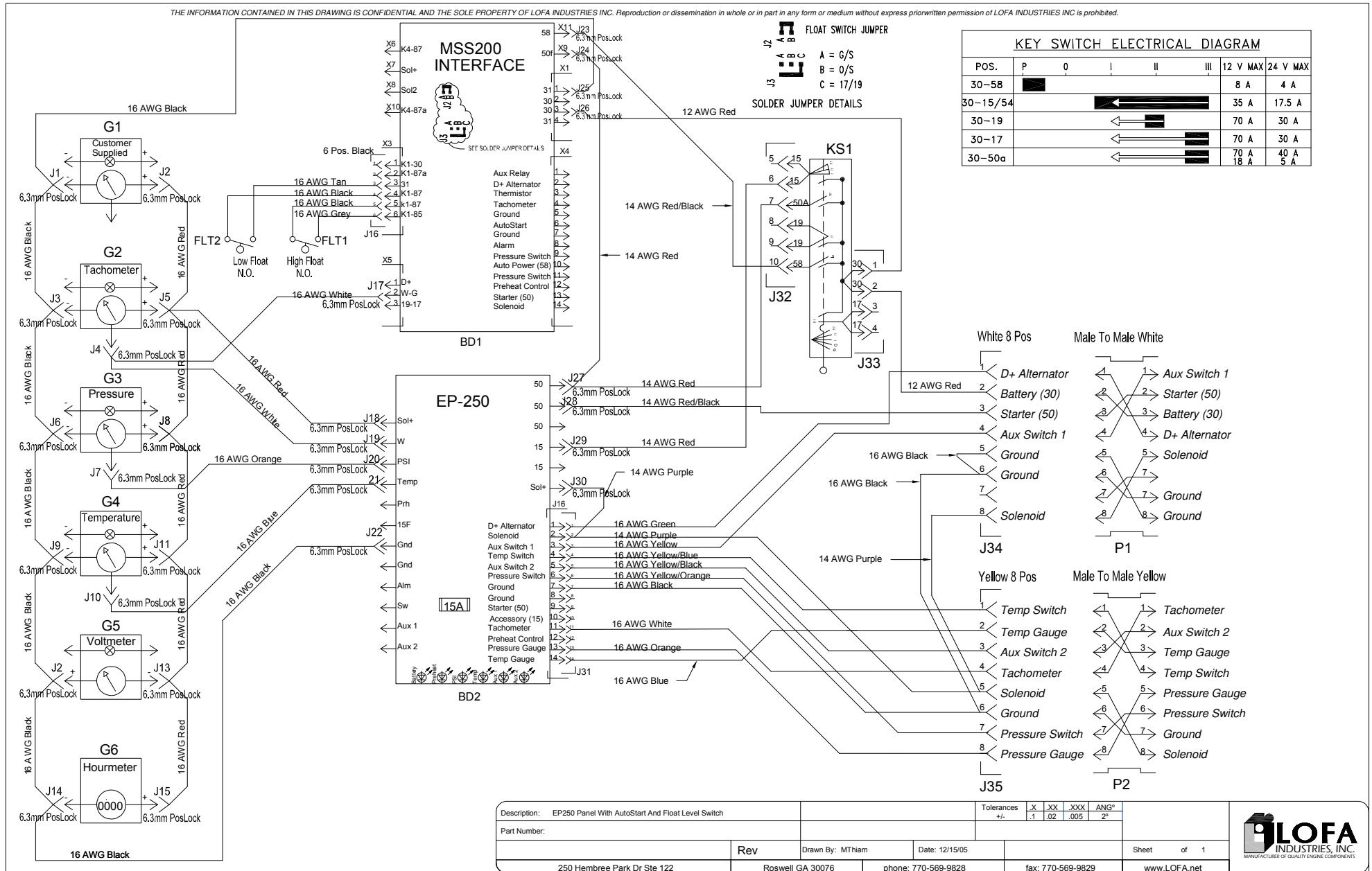
Rev C – 8-Jan-2007. Updated schematics, removed Power Box information.

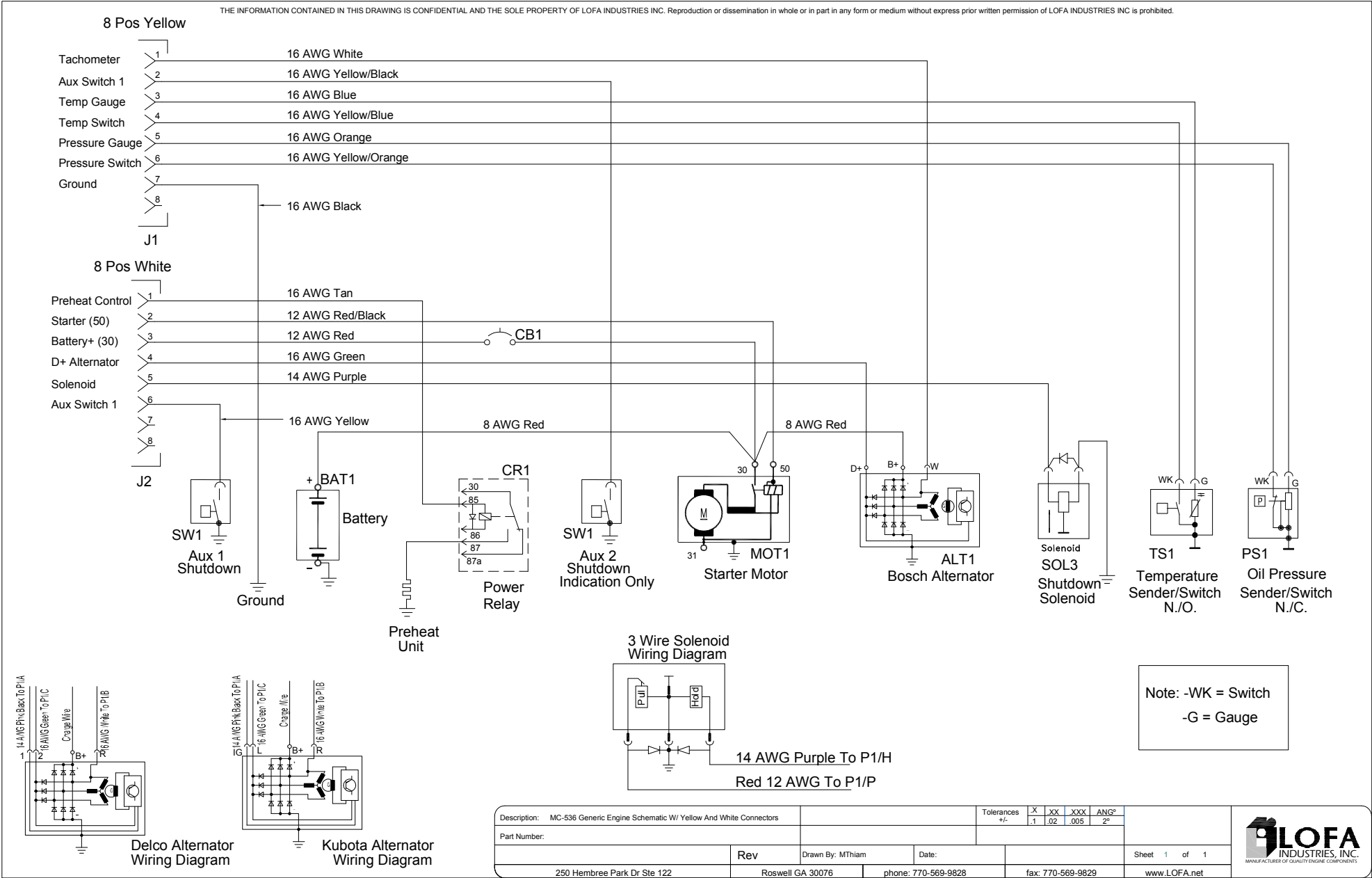
Rev C.1 – 28-Feb-2007. Added part numbers.

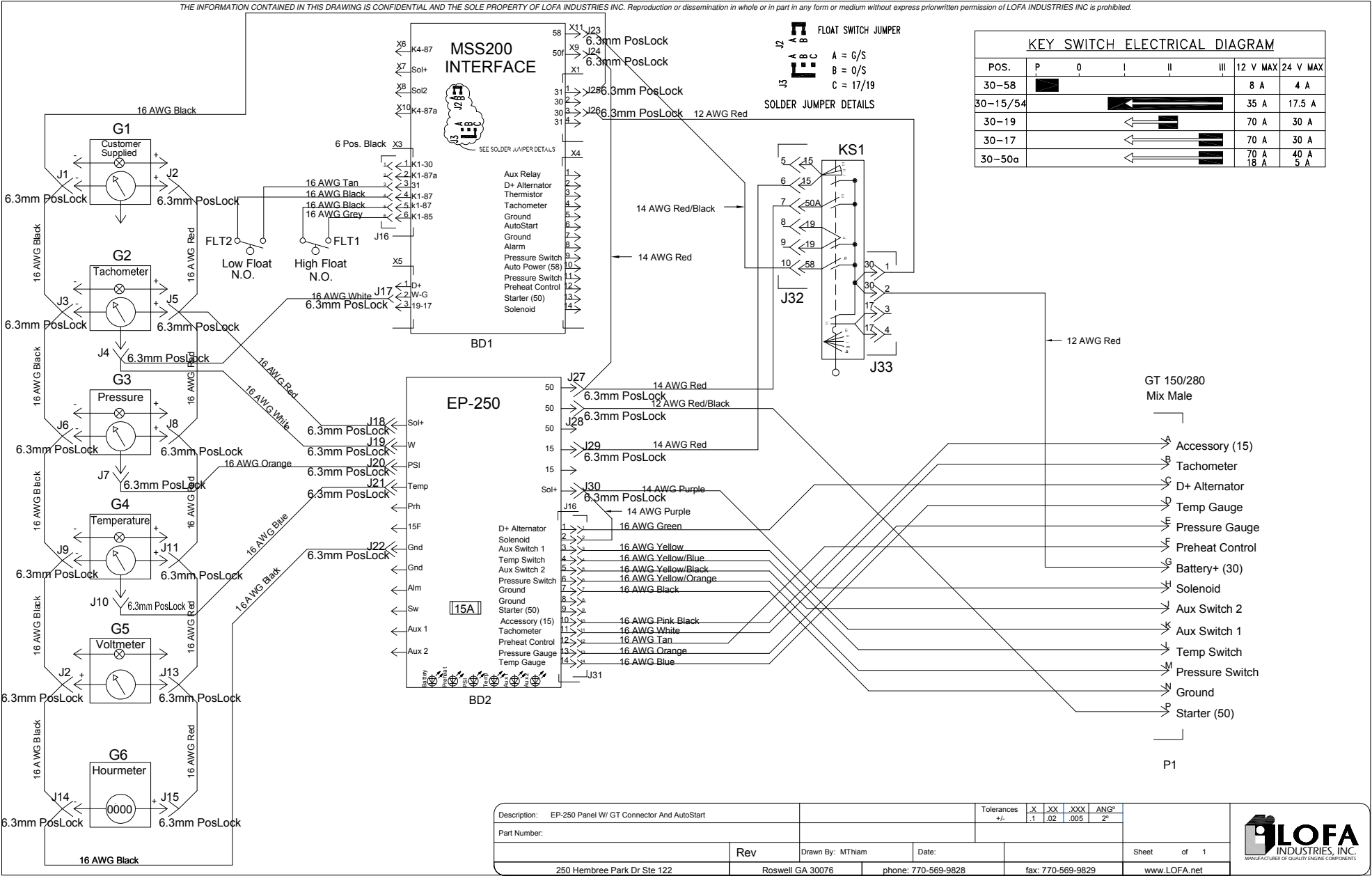
Typical Schematics

The following pages show typical schematics.
Details vary from installation to installation.
See the specific schematics for installation for details.

LOFA EP250 Operation and Troubleshooting



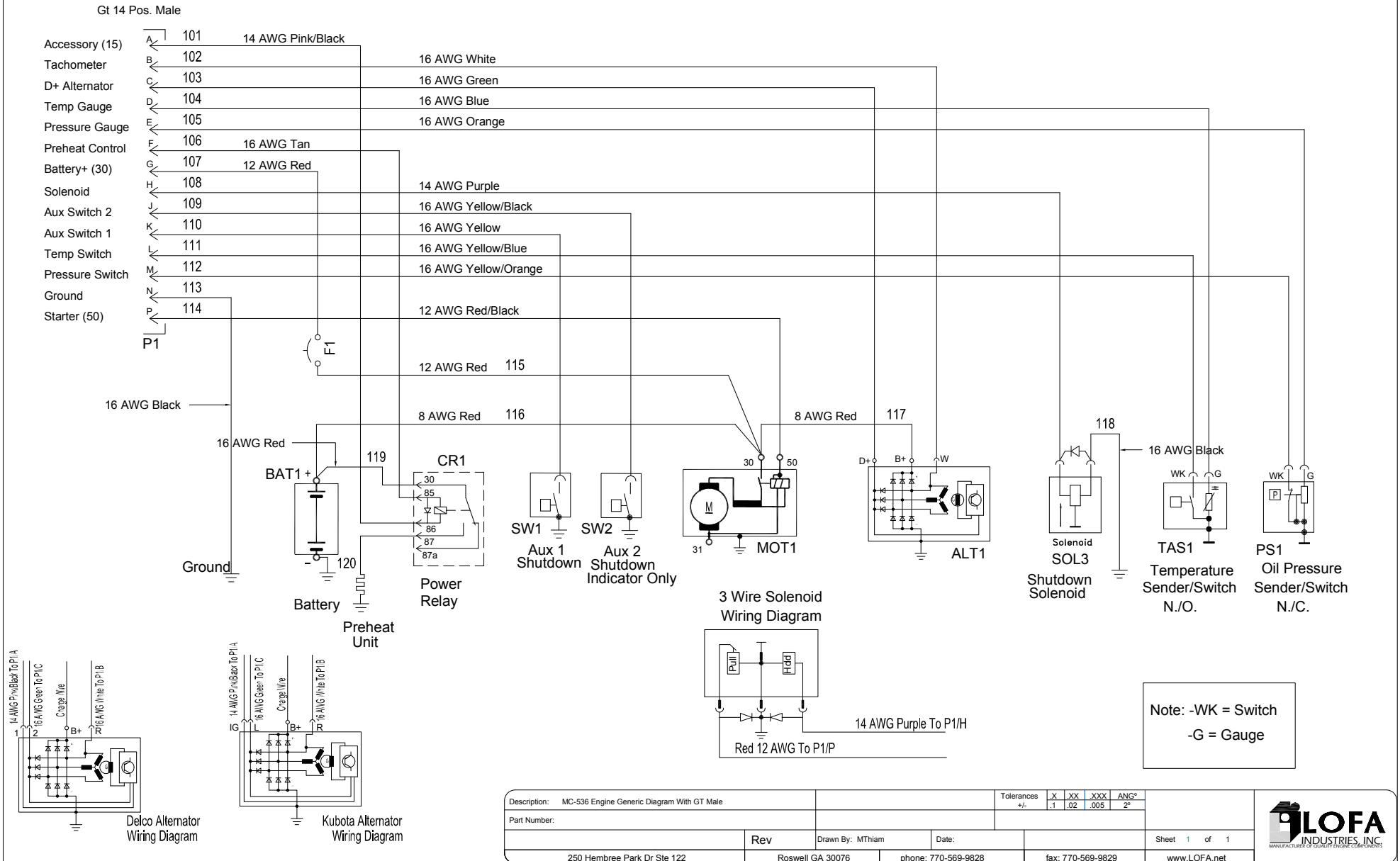




APPENDIX B

LOFA EP250 Operation and Troubleshooting

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APPENDIX C



HYDRO-THROTTLE CONTROL

INSTALLATION INSTRUCTIONS

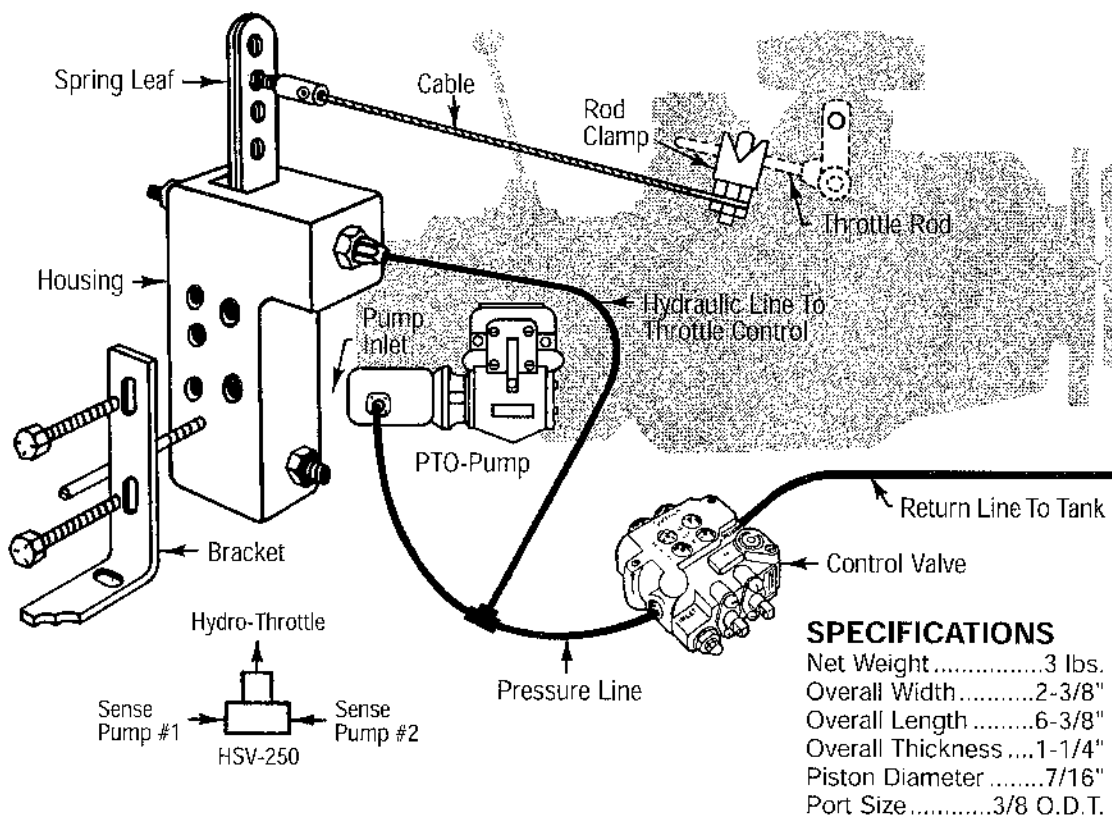
DESCRIPTION

Muncie's STA-9020 Hydro-Throttle Control, used in conjunction with hydraulic powered equipment, will automatically advance engine speed to a pre-selected R.P.M.

The STA-9020 Hydro-Throttle Control is connected into the hydraulic pressure line between the pump and control valve. Activation of any spool of the control valve will cause a pressure build-up in the pressure sensing part of the STA-9020. The internal piston, moving against the leaf springs, causes the springs to pull the throttle linkage to advance the engine speed.

When the control valve is de-activated, pressure drops and allows the STA-9020 to release its pull against the throttle linkage, returning the engine speed to idle. Note: For use on tandem pumps, incorporate Muncie's HSV-250 shuttle valve to isolate two circuits.

Note: For use on tandem pumps, incorporate Muncie's HSV-250 shuttle valve to isolate two circuits.



APPENDIX C

FULLY ADJUSTABLE

The Muncie STA-9020 Hydro-Throttle is fully adjustable to meet a wide variance of operating conditions and system requirements.

The **spring rate** is adjustable by moving the fulcrum screw (5) and changing the number of leaf springs (three are furnished).

Spring tension is adjustable by changing the adjusting screw (4) at the base of the casting.

The **amount of travel** of the accelerator rod is adjustable by changing the actuating rod (9) from spring hold 4 through 1 and by changing the amount of cable slack at engine idle.

The Hydro-Throttle was shipped to you assembled in a medium configuration. The table below indicates five variations of settings. Your unit is set up for variation 2. Try this variation first unless prior installations have indicated another set up is best for your application.

ADJUSTMENT TABLE

Variation Number	No. of Springs	Fulcrum Hole	Spring Tension			Actuating Rod Hole Location
			*Turns	*Pressure	Rate	
1	3	A	3	1100	11X	4
2	3	B	3	780	3X	4
3	3	C	2-1/2	640	Normal	4
4	2	C	2	370	3/4X	4
5	2	D	5/8	300	1/4X	4

***Note:** Apply turns from when the screw (4) just begins to deflect the spring at zero load. Pressure is approximate when piston will begin to move.

INSTALLATION INSTRUCTIONS

1. Attach the "L" shaped mounting bracket to the control (1).
2. Mount the bracket to the engine so that the cable will be in line with the accelerator rod. Modify or bend the mounting bracket if necessary.
3. Attach the cable (10) and actuating rod assembly (9) to hole 4 of the leaf spring.
4. Mount the clamp (11) to the throttle rod and attach cable eyelet to one of the clamp studs.
5. Install a tee in the hydraulic line between the pump and control valve. This tee should be as close as possible to the valve.
6. Connect a 1/4" (minimum) high pressure hose between the tee and the pressure sensing port of the Hydro-Throttle control. Use a small amount of sealer on male threads only. **DO NOT USE TEFLON TAPE.** Do not allow any sealer to enter the piston area of the throttle control.

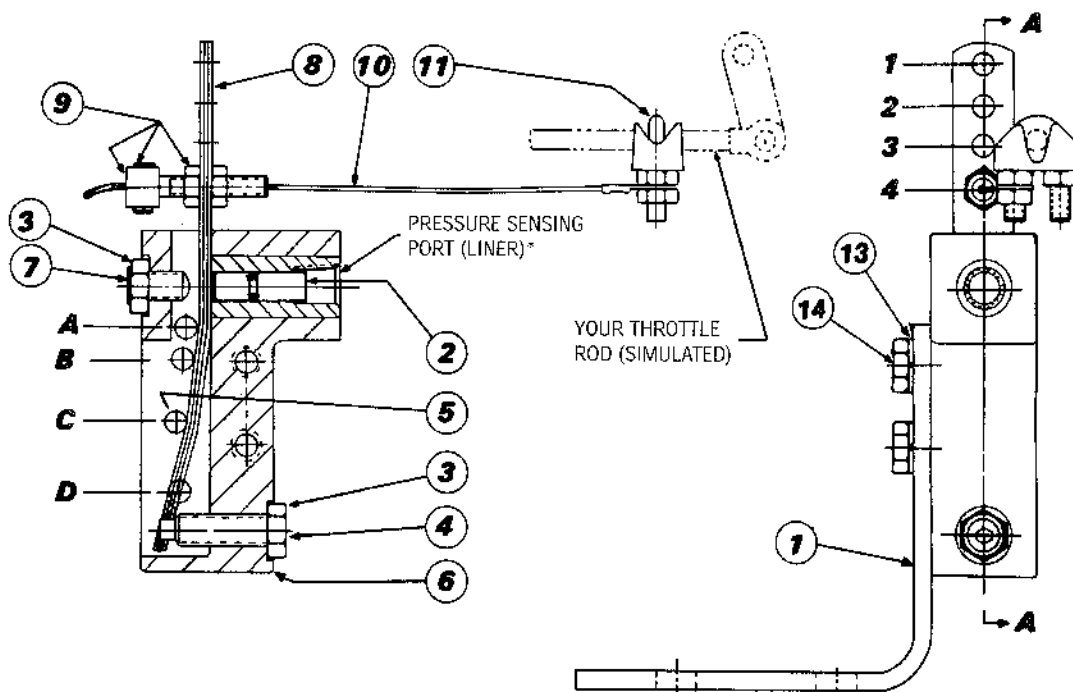
YOU ARE NOW READY TO ADJUST THE HYDRO-THROTTLE.

ADJUSTMENT PROCEDURE

1. Start engine and engage PTO and pump, but do not energize any control valves yet. Allow system to warm up and run at idle without choke (slow idle).
2. Air bleed the pressure line by cracking the fitting at the Hydro-Throttle control.

APPENDIX C

3. Turn speed adjusting screw (7) in until it touches spring. Then turn out one turn temporarily to limit stroke and prevent engine overspeeding.
4. Activate a highly loaded valve circuit. (Bottom out a cylinder to trip the pressure relief valve.) The Hydro-Throttle will attempt to pull accelerator rod.
5. Turn speed adjusting screw (7) outward until the desired engine speed (under load) is reached. Tighten lock nut (3).
6. Return valve to neutral position. The Hydro-Throttle will allow the engine to return to idle. If not, see Trouble Shooting Guide for probable causes.
7. Determine which hydraulic circuit produces the lowest pressure. (Lowering outriggers, boom swing, etc.) Operate this circuit and see if Hydro-Throttle will pull accelerator rod. If not, see Trouble Shooting Guide for probable cause.



STA-9020 PARTS LIST

ITEM	QTY	PART NO.	DESCRIPTION
1	1	28T35118	Bracket
2	1	47TA3790	Piston Assembly
3	1	22T35145	Nut, Jam 3/8-16
4	1	19T35127	Screw 3/8-16 x 2.00 Spring Tension Adjusting
5	1	19T35133	Screw, Fulcrum
6	1	01T35641	Housing (for Screw-In Liner)
7	1	19T35141	Screw 3/8-16 x 1.00 Speed Adjusting
8	3	27T35130	Spring, Leaf
9	1	47TA3796	Rod, Actuating, with Nuts and Set Screws
10	1	47TA3794	Cable Assembly
11	1	47TA3795	Clamp
12	1	47TA3792	Rod/Cable/Clamp Assembly
13	2	21T35143	Lockwasher
14	2	19T35144	Capscrew 5/16-24 x .75 Grade 5
NS*	1	28T35648	Screw-In Liner

APPENDIX C

TROUBLE SHOOTING HINTS

A. Problem: Engine Does Not Idle But Speeds Up When PTO Is Engaged

Probable Cause

1. Control lever stuck open.
2. Low leaf spring tension.
3. Cold oil.

Remedy

1. Return all valves to neutral.
2. Repeat calibration.
3. Warm oil.

B. Problem: Engine Does Not Speed Up When Light Load Is Applied

Probable Cause

1. PTO not engaged.
2. Air in sensing line.
3. Connecting cable.
4. Stops on speed screw.
5. Hot oil.
6. Your engine throttle linkage.
7. Circuit pressure is too low.
8. Excessive leaf spring tension.
9. Excessive leaf spring rate.

Remedy

1. Engage PTO.
2. Bleed line. Crack fitting at control.
3. Reduce slack to minimum.
4. Adjust screw.
5. Allow oil to cool.
6. Oil & repair. Check manufacturer for lighter spring if it's excessive.
7. Revise plumbing to increase spread between your circuit and by-passing pressures.
8. Repeat calibration.
9. Reduce spring rate. See adjustment table.

C. Problem: Engine Does Not Return To Idle After A Load Is Applied

Probable Cause

1. Engine speed excessive.
2. Your engine.
3. Connecting cable.
4. Low leaf spring rate.
5. Low leaf spring rate.
6. Excessive by-passing pressure.

Remedy

1. Reset speed screw adjustment.
2. Make sure it can idle.
3. Check for slack.
4. Increase spring rate. See adjustment table.
5. Repeat calibration.
6. Remove "bottlenecks" or increase line size downstream of the control connection.

WARNING: The Muncie Hydro-Throttle is only to be operated when the vehicle is stationary and the parking brake is set. The installer is responsible for providing a lockout system which makes the Hydro-Throttle inoperable if the parking brake is not set and the transmission is not in neutral.



**Muncie®
Power
Products**

Muncie Power Products, Inc. General Offices and Distribution Center
P.O. Box 548 • Muncie, IN 47308-0548 • (765) 284-7721 • FAX (765) 284-6991
E-mail info@munciepower.com • Web site <http://www.munciepower.com>
Drive Products, Inc., Toronto, Exclusive Agents for Canada



Moduflow™ *Plus* Series

ILP and RFP Low Pressure Filters



Low Pressure Filters

Moduflow™ *Plus* Series

Applications for Moduflow Filters

- Power Unit Fabrication
- Off-line Filter Loops
- Mobile Equipment

The Moduflow filter is widely considered the most versatile filter available on the market. The unique diverter valve assembly, and inside to outside flow through the element, allows the Moduflow to be configured for in-line, in-tank or suction filtration.

The flow diverter minimizes turbulence and pressure loss through the filter, improving system performance.

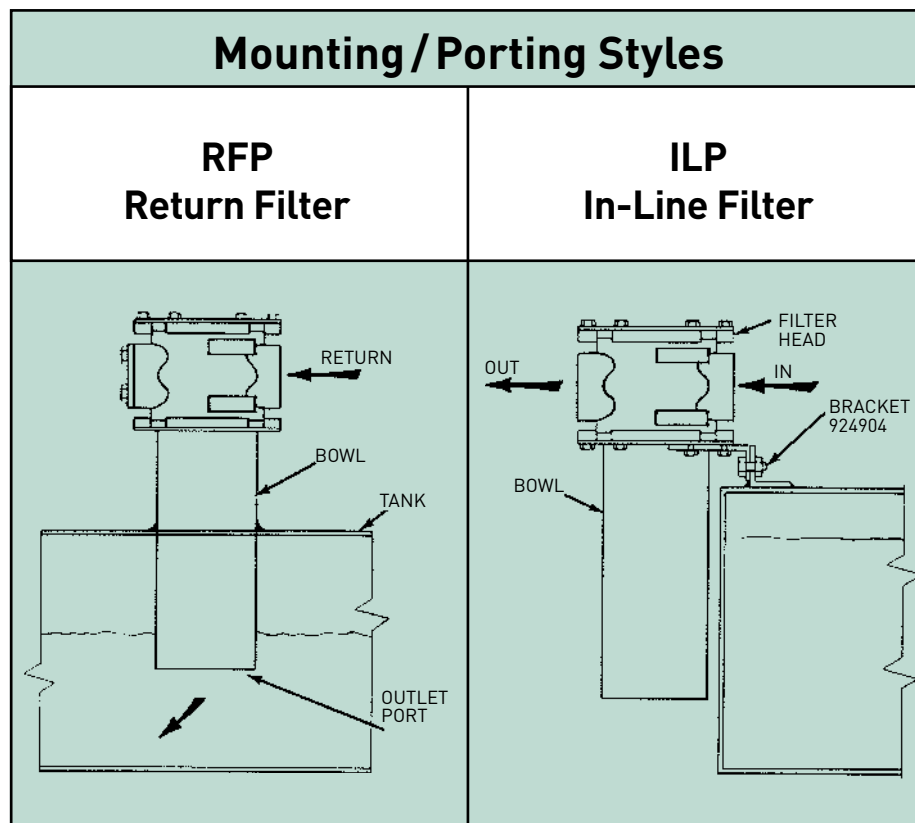
The newly designed closed bottom elements for the RFP and ILP models insures all contamination remains trapped within the element as the filter is serviced.

A wide variety of visual and electrical indicators allows you to know exactly when the element needs to be serviced. There is even a “no element” indicator that can sense when there is not an element installed in the filter.

From top to bottom, the Moduflow filter series provides the high level of filtration and long term dependability so vital to today’s hydraulic systems.



Parker’s new patented Moduflow element was designed with built-in diverter cone and bypass valve, to meet your application needs.



Features

Flanges

- NPT or SAE 3/4" to 2"
- Lightweight aluminum

Cover

- Slotted for quick release
- Lightweight aluminum

Indicators

- Visual or electrical
- Mounted on either side
- Standard "no element" indication

Bowl

- Single or double length
- Durable steel construction

Bypass

(not visible)

- Integral 35 psi bypass replaced with every element change

Element

(not visible)

- Available in cellulose, wire mesh or high performance Microglass III media
- Single or double length



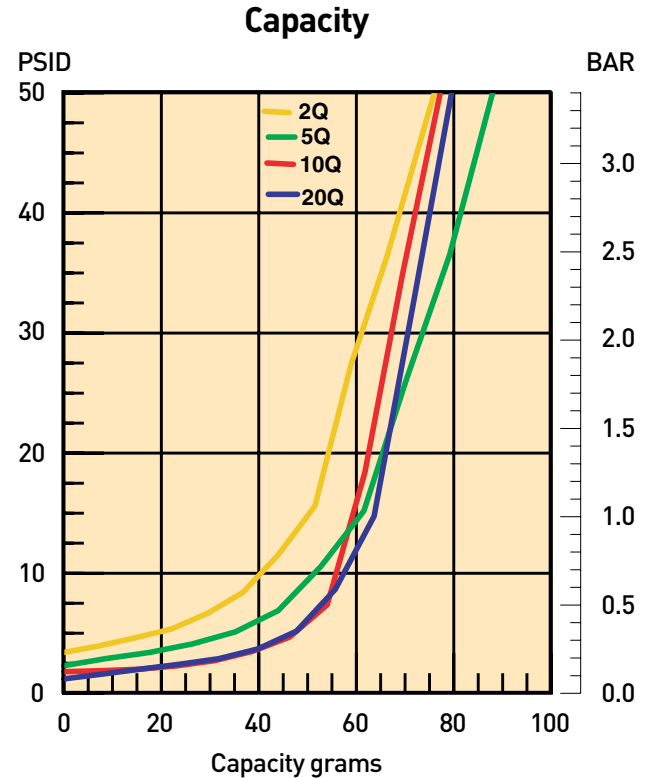
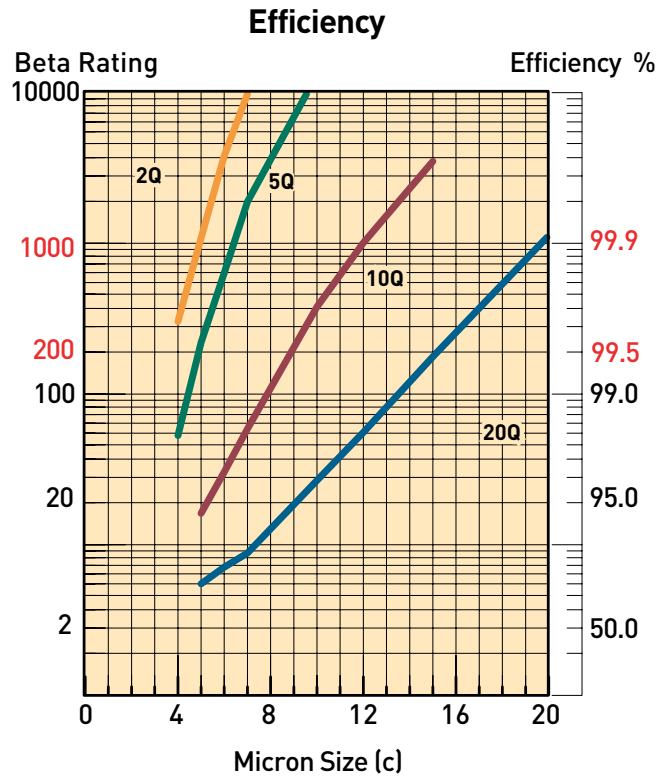
Feature	Advantage	Benefit
<ul style="list-style-type: none"> • Top access element service 	<ul style="list-style-type: none"> • Oil remains in housing • Quicker elements change 	<ul style="list-style-type: none"> • No Spills • Reduced maintenance costs
<ul style="list-style-type: none"> • Slotted cover 	<ul style="list-style-type: none"> • Quick release cover • Cap screws remain in housing 	<ul style="list-style-type: none"> • Reduced maintenance costs • No loose parts to lose
<ul style="list-style-type: none"> • Closed bottom elements 	<ul style="list-style-type: none"> • Removes all contaminant during element service 	<ul style="list-style-type: none"> • No downtime contamination from servicing
<ul style="list-style-type: none"> • Visual or electrical indicators 	<ul style="list-style-type: none"> • Know exactly when to service elements 	<ul style="list-style-type: none"> • Helps prevent bypass condition • No premature disposal
<ul style="list-style-type: none"> • Flange face ports 	<ul style="list-style-type: none"> • Flexible mounting (3/4" to 2") 	<ul style="list-style-type: none"> • Easy plumbing to your system

Low Pressure Filters

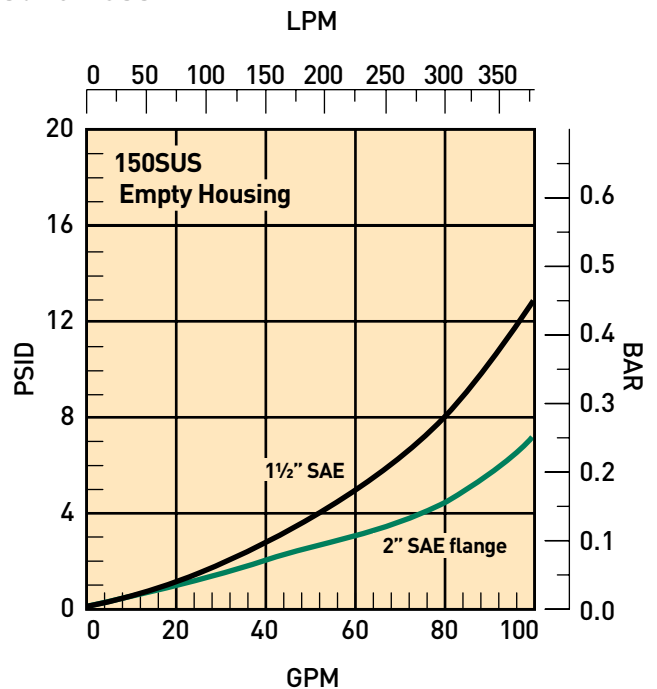
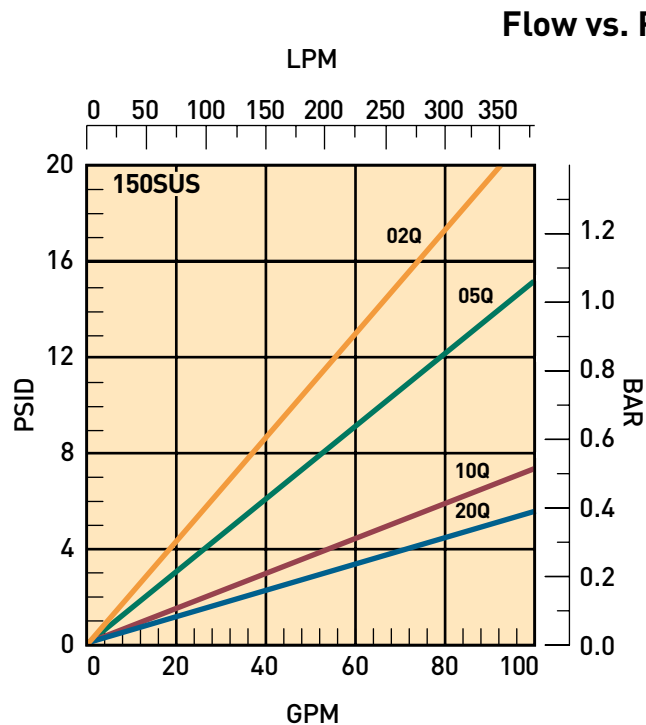
Moduflow™ Plus Series

APPENDIX D

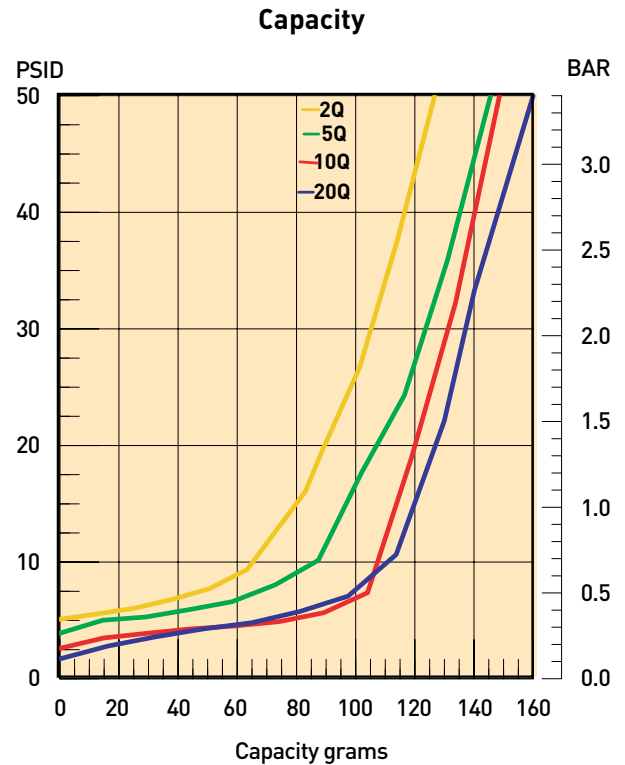
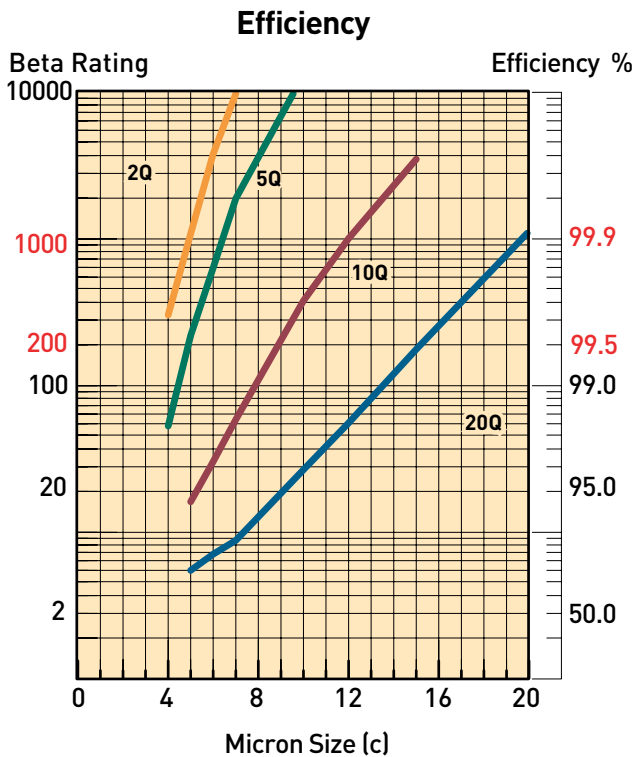
RFP-1 & ILP-1 Element Performance



Multipass tests run @ 40 gpm to 50 psid terminal - 5mg/L BUGL

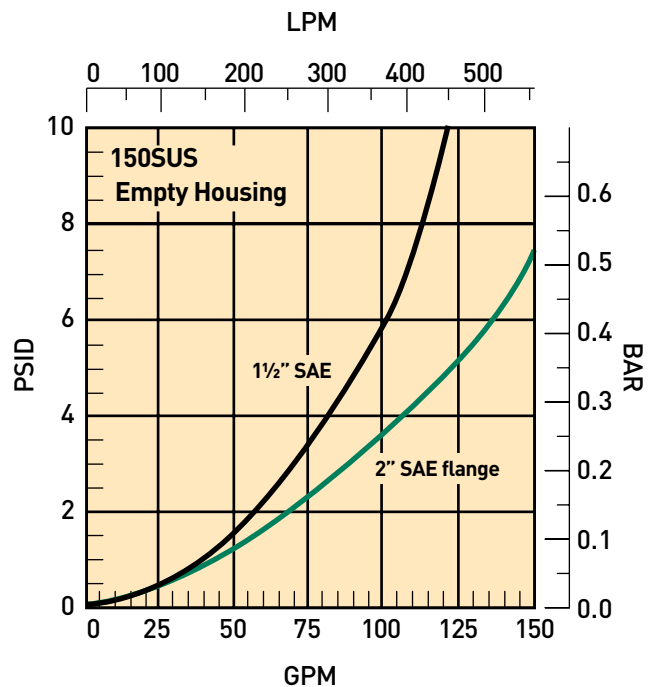
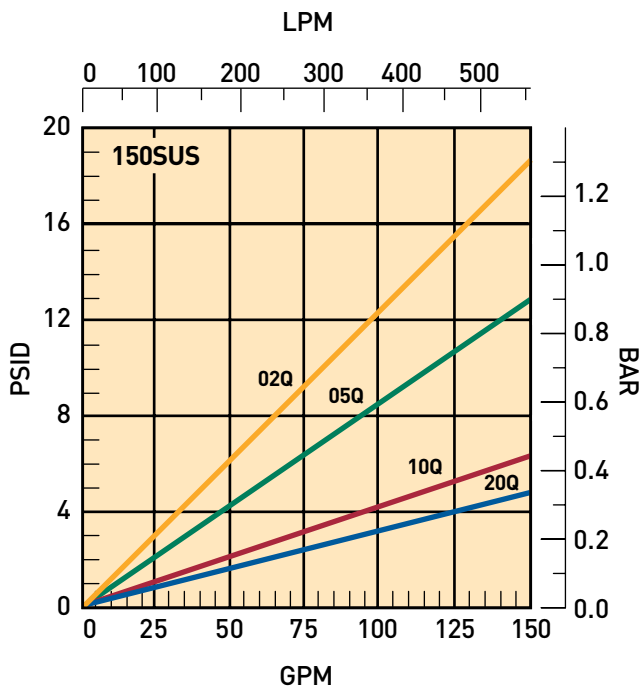


RFP-2 & ILP-2 Element Performance



Multipass tests run @ 80 gpm to 50 psid terminal - 5mg/L BUGL

Flow vs. Pressure Loss



Low Pressure Filters

Moduflow™ *Plus* Series

Specifications: RFP, ILP

Pressure Ratings:

Maximum Allowable Operating Pressure (MAOP): 200 psi (13.8 bar)

Design Safety Factor: 2:1

Rated Fatigue Pressure: 150 psi (10.3 bar)

Element Burst Rating: 70 psid (4.8 bar)

Filter Materials:

Head, Cover, Flanges: die cast aluminum
Bowl: steel

Operating Temperatures:

Nitrile: -40°F to 225°F (-40°C to 107°C)

Fluorocarbon: -15°F to 275°F (-26°C to 135°C)

Weight (approximate):

Single: 20 lbs. (9.1 kg)

Double: 25 lbs. (11.3 kg)

Indicators:

Visual (optional)

Electrical (optional) 15A @ 250VAC / .5A @ 125 VDC

Electrical ("D" option) 5A @ 250VAC / 3A @ 28 VDC

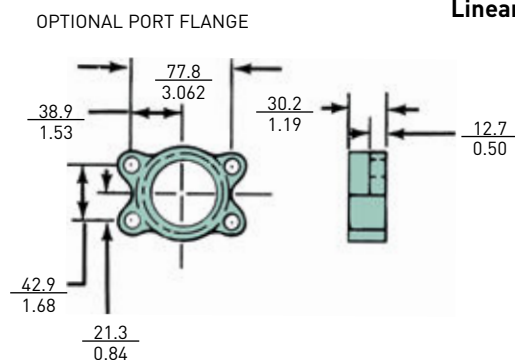
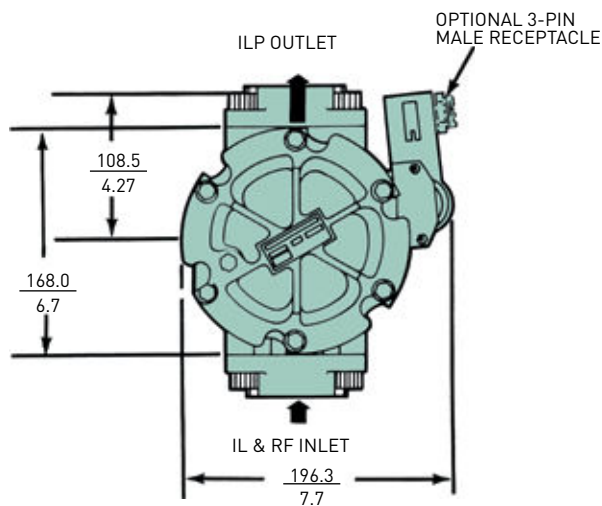
Color Coding:

White (normally closed)

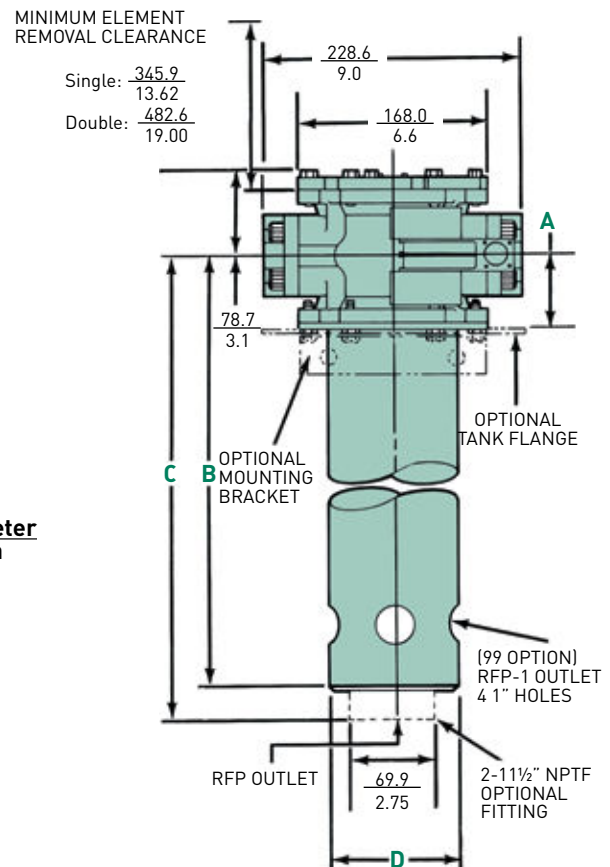
Red (normally open)

Black (common)

Model	Dimensions: <small>mm inch</small>			
	A	B	C	D
RFP-1 without optional 2" fitting	<u>65.0</u> 2.56	<u>330.2</u> 13.0	—	<u>110.0</u> 4.3
ILP-1	<u>65.0</u> 2.56	<u>330.2</u> 13.0	N/A	<u>110.0</u> 4.3
RFP-1 with optional 2" fitting	<u>68.3</u> 2.69	—	<u>383.4</u> 15.07	<u>114.0</u> 4.5
RFP-2	<u>68.3</u> 2.69	<u>617.5</u> 24.31	<u>623.8</u> 24.56	<u>114.0</u> 4.5
ILP-2	<u>68.3</u> 2.69	<u>617.5</u> 24.31	N/A	<u>114.0</u> 4.5



Linear Measure: millimeter
inch



ISO 4406 Code

Cleanliness levels are defined by three numbers divided by slashes (/). These numbers correspond to 4, 6, and 14 micron, in that order. Each number refers to an ISO Range Code, which is determined by the number of particles for that size (4, 6, & 14µm) and larger present in 1 ml of fluid. Each range is double the range below. Refer to the chart below to see the actual ranges.

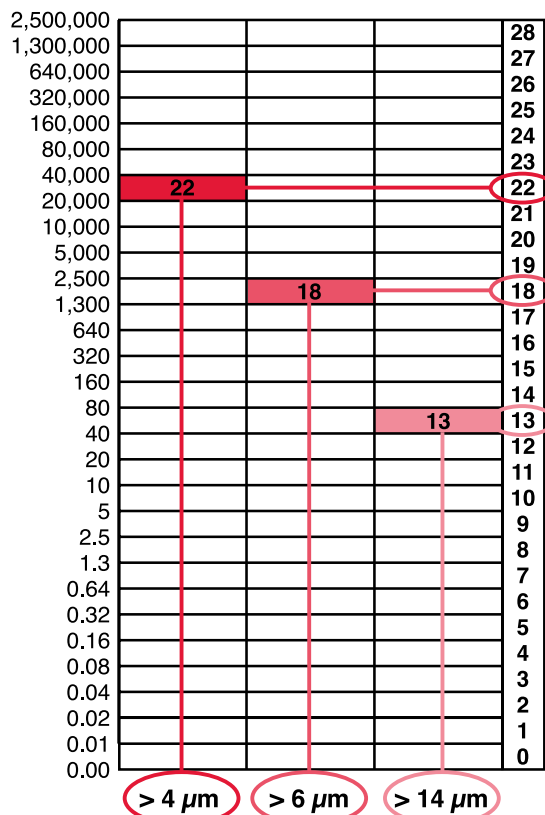
Example:

larger than 4µm = 22,340

larger than 6µm = 1,950

larger than 14µm = 43

ISO Code = 22 / 18 / 13



Achieving the appropriate cleanliness level in a system

The only way to achieve and maintain the appropriate cleanliness level in a hydraulic or lubrication system, is to implement a comprehensive filtration program. HYDAC offers all of the products that are needed to do just that! - They include:

Solid Contamination

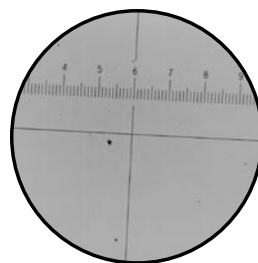
- pressure filters
- return line filters
- offline filtration loops
- oil transfer units for precleaning of new oil
- portable and online contamination monitors
- reservoir breathers and filler/breathers

Water Content

- water content sensors
- reservoir breathers with silica gel desiccant
- vacuum dehydration water removal units
- water removal elements

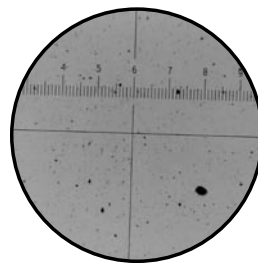
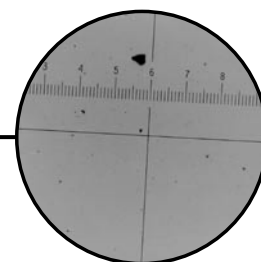
Fluid Analysis

- bottle sampling kits
- complete analysis kits



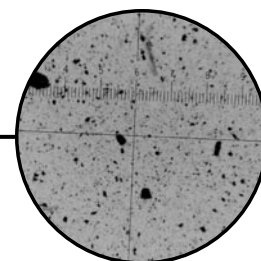
14/12/9

17/15/12



20/18/15

23/21/18



Finding the cleanliness level required by a system

1. Starting at the left hand column, select the most sensitive component used in the system.
2. Move to the right to the column that describes the system pressure and conditions.
3. Here you will find the recommended ISO class level, and recommended element micron rating.

	Low/Medium Pressure Under 2000 psi (moderate conditions)		High Pressure 2000 to 2999 psi (low/medium with severe conditions ¹)		Very High Pressure 3000 psi and over (high pressure with severe conditions ¹)	
	ISO Target Levels	Micron Ratings	ISO Target Levels	Micron Ratings	ISO Target Levels	Micron Ratings
Pumps						
Fixed Gear or Fixed Vane	20/18/15	20	19/17/14	10	18/16/13	5
Fixed Piston	19/17/14	10	18/16/13	5	17/15/12	3
Variable Vane	18/16/13	5	17/15/12	3	not applicable	not applicable
Variable Piston	18/16/13	5	17/15/12	3	16/14/11	3 ²
Valves						
Check Valve	20/18/15	20	20/18/15	20	19/17/14	10
Directional (solenoid)	20/18/15	20	19/17/14	10	18/16/13	5
Standard Flow Control	20/18/15	20	19/17/14	10	18/16/13	5
Cartridge Valve	19/17/14	10	18/16/13	5	17/15/12	3
Proportional Valve	17/15/12	3	17/15/12	3	16/14/11	3 ²
Servo Valve	16/14/11	3 ²	16/14/11	3 ²	15/13/10	3 ²
Actuators						
Cylinders, Vane Motors, Gear Motors	20/18/15	20	19/17/14	10	18/16/13	5
Piston Motors, Swash Plate Motors	19/17/14	10	18/16/13	5	17/15/12	3
Hydrostatic Drives	16/15/12	3	16/14/11	3 ²	15/13/10	3 ²
Test Stands	15/13/10	3 ²	15/13/10	3 ²	15/13/10	3 ²
Bearings						
Journal Bearings	17/15/12	3	not applicable	not applicable	not applicable	not applicable
Industrial Gearboxes	17/15/12	3	not applicable	not applicable	not applicable	not applicable
Ball Bearings	15/13/10	3 ²	not applicable	not applicable	not applicable	not applicable
Roller Bearings	16/14/11	3 ²	not applicable	not applicable	not applicable	not applicable

1. Severe conditions may include high flow surges, pressure spikes, frequent cold starts, extremely heavy duty use, or the presence of water
2. Two or more system filters of the recommended rating may be required to achieve and maintain the desired Target Cleanliness Level.



FREE Poster!

The information on these two pages is also available on our **ISO Cleanliness Guidelines** poster. Visit our web site to request your FREE copy.

www.hydacusa.com/poster

MATERIAL SAFETY DATA SHEET
LEAD ACID BATTERY WET, FILLED WITH
ACID
 (US, CN, EU Version for International Trade)

SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: Lead Acid Battery Wet, Filled With Acid
OTHER PRODUCT NAMES: Electric Storage Battery, SLI or Industrial Battery, UN2794

MANUFACTURER: East Penn Manufacturing Company, Inc.
DIVISION: Dekal Road
ADDRESS: Lyon Station, PA 19536 USA

EMERGENCY TELEPHONE NUMBERS: US: CHEMTREC 1-800-424-9300
 CN: CHEMTREC 1-800-424-9300
 Outside US: +1-703-527-3887

NON-EMERGENCY HEALTH/SAFETY INFORMATION: 1-610-682-6361

CHEMICAL FAMILY: This product is a wet lead acid storage battery. May also include gel/absorbed electrolyte type lead acid battery types.

PRODUCT USE: Industrial/Commercial electrical storage batteries.

This product is considered a Hazardous Substance, Preparation or Article that is regulated under US-OSHA; CAN-WHMIS; IOSH; ISO; UK-CHIP; or EU Directives (67/548/EEC-Dangerous Substance Labeling, 98/24/EC-Chemical Agents at Work, 99/45/EC-Preparation Labeling, 2001/58/EC-MSDS Content, and 1907/2006/EC-REACH), and an MSDS/SDS is required for this product considering that when used as recommended or intended, or under ordinary conditions, it may present a health and safety exposure or other hazard.

Additional Information

This product may not be compatible with all environments, such as those containing liquid solvents or extreme temperature or pressure. Please request information if considering use under extreme conditions or use beyond current product labeling.

SECTION 2: HAZARDS IDENTIFICATION**GHS Classification:**

Health	Environmental	Physical
Acute Toxicity – Not listed (NL) Eye Corrosion – Corrosive* Skin Corrosion – Corrosive* Skin Sensitization – NL Mutagenicity/Carcinogenicity – NL Reproductive/Developmental – NL Target Organ Toxicity (Repeated) – NL	Aquatic Toxicity – NL	NFPA – Flammable gas, hydrogen (during charging) CN - NL EU - NL

*as sulfuric acid

GHS Label: Lead Acid Battery, Wet

Symbols: C (Corrosive)

**Hazard Statements**

Contact with internal components may cause irritation of severe burns. Irritating to eyes, respiratory system, and skin.

Precautionary Statements

Keep out of reach of children. Keep containers tightly closed. Avoid heat, sparks, and open flame while charging batteries. Avoid contact with internal acid.

EMERGENCY OVERVIEW: May form explosive air/gas mixture during charging. Contact with internal components may cause irritation or severe burns. Irritating to eyes, respiratory system, and skin.

APPENDIX F

MATERIAL SAFETY DATA SHEET *LEAD ACID BATTERY WET, FILLED WITH ACID*

(US, CN, EU Version for International Trade)

Prolonged inhalation or ingestion may result in serious damage to health. Pregnant women exposed to internal components may experience reproductive/developmental effects.

POTENTIAL HEALTH EFFECTS:

- EYES:** Direct contact of internal electrolyte liquid with eyes may cause severe burns or blindness.
SKIN: Direct contact of internal electrolyte liquid with the skin may cause skin irritation or damaging burns.
INGESTION: Swallowing this product may cause severe burns to the esophagus and digestive tract and harmful or fatal lead poisoning. Lead ingestion may cause nausea, vomiting, weight loss, abdominal spasms, fatigue, and pain in the arms, legs and joints.
INHALATION: Respiratory tract irritation and possible long term effects.

ACUTE HEALTH HAZARDS:

Repeated or prolonged contact may cause mild skin irritation.

CHRONIC HEALTH HAZARDS:

Lead poisoning if persons are exposed to internal components of the batteries. Lead absorption may cause nausea, vomiting, weight loss, abdominal spasms, fatigue, pain in the arms, legs and joints. Other effects may include central nervous system damage, kidney dysfunction, and potential reproductive effects. Chronic inhalation of sulfuric acid mist may increase the risk of lung cancer.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:

Respiratory and skin diseases may predispose one to acute and chronic effects of sulfuric acid and/or lead. Children and pregnant women must be protected from lead exposure. Persons with kidney disease may be at increased risk of kidney failure.

Additional Information

No health effects are expected related to normal use of this product as sold.

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENTS (Chemical/Common Names):

Lead, inorganic	7439-92-1	43-70 (average: 65)	231-100-4
Sulfuric acid	7664-93-9	20-44 (average: 25)	231-639-5
Antimony	7440-36-0	0-4 (average: 1)	231-146-5
Arsenic	7440-38-2	<0.01	231-148-6
Polypropylene	9003-07-0	5-10 (average: 8)	NA
NA – Not applicable/ND – Not determined			

Additional Information

These ingredients reflect components of the finished product related to performance of the product as distributed into commerce.

SECTION 4: FIRST AID MEASURES

- EYE CONTACT:** Flush eyes with large amounts of water for at least 15 minutes. Seek immediate medical attention if eyes have been exposed directly to acid.
SKIN CONTACT: Flush affected area(s) with large amounts of water using deluge emergency shower, if available, shower for at least 15 minutes. Remove contaminated clothing. If symptoms persist, seek medical attention.
INGESTION: If swallowed, give large amounts of water. Do NOT induce vomiting or aspiration into the lungs may occur and can cause permanent injury or death.
INHALATION: If breathing difficulties develop, remove person to fresh air. If symptoms persist, seek medical attention.

SECTION 5: FIRE-FIGHTING MEASURES

SUITABLE/UNSUITABLE EXTINGUISHING MEDIA:

PAGE 2 OF 8
Inc.

East Penn Manufacturing Co.,

MATERIAL SAFETY DATA SHEET

LEAD ACID BATTERY WET, FILLED WITH

ACID

(US, CN, EU Version for International Trade)

Dry chemical, carbon dioxide, water, foam. Do not use water on live electrical circuits.

SPECIAL FIRE FIGHTING PROCEDURES & PROTECTIVE EQUIPMENT:

Use appropriate media for surrounding fire. Do not use carbon dioxide directly on cells. Avoid breathing vapors. Use full protective equipment (bunker gear) and self-contained breathing apparatus.

UNUSUAL FIRE AND EXPLOSION HAZARDS:

Batteries evolve flammable hydrogen gas during charging and may increase fire risk in poorly ventilated areas near sparks, excessive heat or open flames.

SPECIFIC HAZARDS IN CASE OF FIRE:

Thermal shock may cause battery case to crack open. Containers may explode when heated.

Additional Information

Firefighting water runoff and dilution water may be toxic and corrosive and may cause adverse environmental impacts.

SECTION 6: ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS:

Avoid Contact with Skin. Neutralize any spilled electrolyte with neutralizing agents, such as soda ash, sodium bicarbonate, or very dilute sodium hydroxide solutions.

ENVIRONMENTAL PRECATIONS:

Prevent spilled material from entering sewers and waterways.

SPILL CONTAINMENT & CLEANUP METHODS/MATERIALS:

Add neutralizer/absorbent to spill area. Sweep or shovel spilled material and absorbent and place in approved container.

Dispose of any non-recyclable materials in accordance with local, state, provincial or federal regulations.

Additional Information

Lead acid batteries and their plastic cases are recyclable. Contact your East Penn representative for recycling information.

SECTION 7: HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING AND STORAGE:

- Keep containers tightly closed when not in use.
- If battery case is broken, avoid contact with internal components.
- Do not handle near heat, sparks, or open flames.
- Protect containers from physical damage to avoid leaks and spills.
- Place cardboard between layers of stacked batteries to avoid damage and short circuits.
- Do not allow conductive material to touch the battery terminals. A dangerous short-circuit may occur and cause battery failure and fire.

OTHER PRECAUTIONS (e.g.; Incompatibilities):

Keep away from combustible materials, organic chemicals, reducing substances, metals, strong oxidizers and water.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS/SYSTEM DESIGN INFORMATION:

Charge in areas with adequate ventilation.

VENTILATION:

General dilution ventilation is acceptable.

RESPIRATORY PROTECTION:

Not required for normal conditions of use. See also special firefighting procedures (Section 5).

EYE PROTECTION:

Wear protective glasses with side shields or goggles.

SKIN PROTECTION:

Wear chemical resistant gloves as a standard procedure to prevent skin contact.

OTHER PROTECTIVE CLOTHING OR EQUIPMENT: Chemically-impervious apron and face shield recommended when adding water or electrolyte to batteries.

Wash Hands after handling.

EXPOSURE GUIDELINES & LIMITS:

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Inc.

East Penn Manufacturing Co.,

APPENDIX F

MATERIAL SAFETY DATA SHEET LEAD ACID BATTERY WET, FILLED WITH ACID (US, CN, EU Version for International Trade)

EXPOSURE GUIDELINES & LIMITS:

OSHA	Permissible Exposure Limit (PEL/TWA)	Lead, inorganic (as Pb)	0.05 mg/m ³
		Sulfuric acid	1 mg/m ³
		Antimony	0.5 mg/m ³
		Arsenic	0.01 mg/m ³
ACGIH	2007 Threshold Limit Value (TLV)	Lead, inorganic (as Pb)	0.05 mg/m ³
		Sulfuric acid	0.2 mg/m ³
		Antimony	0.5 mg/m ³
		Arsenic	0.01 mg/m ³
Quebec	Permissible Exposure Value (PEV)	Lead, inorganic (as Pb)	0.15 mg/m ³
		Sulfuric acid	1 mg/m ³ TWA
			3 mg/m ³ STEV
		Antimony	0.5 mg/m ³
		Arsenic	0.1 mg/m ³
Ontario	Occupational Exposure Level (OEL)	Lead (designated substance)	0.10 mg/m ³
		Sulfuric acid	1 mg/m ³ TWAEV
			3 mg/m ³ STEV
		Antimony	0.5 mg/m ³
		Arsenic (designated substance)	0.01 mg/m ³
Netherlands	Maximaal Aanvaarde Concentratie (MAC)	Lead, inorganic (as Pb)	0.15 mg/m ³
		Sulfuric acid	1 mg/m ³
Germany	Maximale Arbeitsplatzkonzentrationen (MAK)	Lead, inorganic (as Pb)	0.1 mg/m ³
		Sulfuric acid	1 mg/m ³ TWA
			2 mg/m ³ STEL
		Antimony	0.5 mg/m ³
United Kingdom	Occupational Exposure Standard (OES)	Lead	0.15 mg/m ³
		Antimony	0.5 mg/m ³
		Arsenic	0.1 mg/m ³

TWA – 8-Hour Time Weighted Average/ STE – Short Term Exposure / mg/m³ – milligrams per cubic meter of air/ NE – Not Established

Additional Information

- Batteries are housed in polypropylene cases which are regulated as total dust or respirable dust only when they are ground up during recycling. The OSHA PEL for dust is 15 mg/m³ as total dust or 5 mg/m³ as respirable dust.
- May be required to meet Domestic Requirements for a Specific Destination(s).

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE:	Industrial/commercial lead acid battery
ODOR:	Odorless
ODOR THRESHOLD:	NA
PHYSICAL STATE:	Sulfuric Acid: Liquid; Lead: solid
pH:	<1
BOILING POINT:	235-240° F (as sulfuric acid)
MELTING POINT:	NA
FREEZING POINT:	NA
VAPOR PRESSURE:	10 mmHg
VAPOR DENSITY (AIR = 1):	> 1
SPECIFIC GRAVITY (H ₂ O = 1):	1.27–1.33
EVAPORATION RATE (n-BuAc=1):	< 1
SOLUBILITY IN WATER:	100% (as sulfuric acid)
FLASH POINT:	Below room temperature (as hydrogen gas)
AUTO-IGNITION TEMPERATURE:	NA
LOWER EXPLOSIVE LIMIT (LEL):	4% (as hydrogen gas)
UPPER EXPLOSIVE LIMIT (UEL):	74% (as hydrogen gas)
PARTITION COEFFICIENT:	NA
VISCOSITY (poise @ 25° C):	Not Available

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DECOMPOSITION TEMPERATURE: Not Available

FLAMMABILITY/HMIS HAZARD CLASSIFICATIONS (US/CN/EU): As sulfuric acid

HEALTH: 3 FLAMMABILITY: 0 REACTIVITY: 2

SECTION 10: STABILITY AND REACTIVITY

STABILITY:	This product is stable under normal conditions at ambient temperature.
INCOMPATIBILITY (MATERIAL TO AVOID):	Strong bases, combustible organic materials, reducing agents, finely divided metals, strong oxidizers, and water.
HAZARDOUS DECOMPOSITION BY-PRODUCTS:	Thermal decomposition will produce sulfur dioxide, sulfur trioxide, carbon monoxide, sulfuric acid mist, and hydrogen.
HAZARDOUS POLYMERIZATION:	Will not occur
CONDITIONS TO AVOID:	Overcharging, sources of ignition

SECTION 11: TOXICOLOGICAL INFORMATION

ACUTE TOXICITY (Test Results Basis and Comments):

Sulfuric acid: LD₅₀, Rat: 2140 mg/kg
 LC₅₀, Guinea pig: 510 mg/m³

Lead: No data available for elemental lead

SUBCHRONIC/CHRONIC TOXICITY (Test Results and Comments):

Repeated exposure to lead and lead compounds in the workplace may result in nervous system toxicity. Some toxicologists report that abnormal conduction velocities in person with blood lead levels of 50 µg/100 ml or higher. Heavy lead exposure may result in central nervous system damage, encephalopathy and damage to the blood-forming (hematopoietic) tissues.

Additional Information

- Very little chronic toxicity data available for elemental lead.
- Lead is listed by IARC as a 2B carcinogen: possible carcinogen in humans. Arsenic is listed by IARC, ACGIH, and NTP as a carcinogen, based on studies with high doses overlong periods of time. The other ingredients in this product, present at equal to or greater than 0.1% of the product, are not listed by OSHA, NTP, or IARC as suspect carcinogens.
- The 19th Amendment to EC Directive 67/548/EEC classified lead compounds, but not lead in metal form, as possibly toxic to reproduction. Risk phrase 61: May cause harm to the unborn child, applies to lead compounds, especially soluble forms.

SECTION 12: ECOLOGICAL INFORMATION

PERSISTENCE & DEGRADABILITY:

Lead is very persistent in soils and sediments. No data available on biodegradation.

BIO-ACCUMULATIVE POTENTIAL (Including Mobility):

Mobility of metallic lead between ecological compartments is low. Bioaccumulation of lead occurs in aquatic and terrestrial animals and plants, but very little bioaccumulation occurs through the food chain. Most studies have included lead compounds, not solid inorganic lead.

AQUATIC TOXICITY (Test Results & Comments):

Sulfuric acid: 24-hour LC₅₀, fresh water fish (*Brachydanio rerio*): 82 mg/l
 96-hour LOEC, fresh water fish (*Cyprinus carpio*): 22 mg/l (lowest observable effect concentration)

Lead (metal): No data available

Additional Information

- No known effects on stratospheric ozone depletion.
- Volatile organic compounds: 0% (by Volume)
- Water Endangering Class (WGK): NA

SECTION 13: DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD:

Follow local, State/Provincial, and Federal/National regulations applicable to as-used, end-of-life characteristics to be determined by end-user.

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HAZARDOUS WASTE**CLASS/CODE:**

US - Not applicable to finished product as manufactured for distribution into commerce.
 CN – Not applicable to finished product as manufactured for distribution into commerce.
 EWC – Not applicable to finished product as manufactured for distribution into commerce.

Additional Information

Not Included – **Recycle** or dispose as allowed by local jurisdiction for the end-of-life characteristics as-disposed.

SECTION 14: TRANSPORT INFORMATION**GROUND – US-DOT/CAN-TDG/EU-ADR/APEC-ADR:**

Proper Shipping Name	Batteries, Wet, Filled with Acid	ID Number	UN2794
Hazard Class	8	Labels	Corrosive
Packing Group	III		

AIRCRAFT – ICAO-IATA:

Proper Shipping Name	Batteries, Wet, Filled with Acid	ID Number	UN2794
Hazard Class	8	Labels	Corrosive
Packing Group	III		

Reference IATA packing instructions 870

VESSEL – IMO-IMDG:

Proper Shipping Name	Batteries, Wet, Filled with Acid	ID Number	UN2794
Hazard Class	8	Labels	Corrosive
Packing Group	III		

Reference IMDG packing instructions P801

Additional Information

Transport requires proper packaging and paperwork, including the Nature and Quantity of goods, per applicable origin/destination/customs points as-shipped.

SECTION 15: REGULATORY INFORMATION**INVENTORY STATUS:**

All components are listed on the TSCA, EINECS/ELINCS; and DSL, unless noted otherwise below.

U.S. FEDERAL REGULATIONS:

TSCA Section 8b – Inventory Status: All chemicals comprising this product are either exempt or listed on the TSCA Inventory.

TSCA Section 12b – Export Notification: If the finished product contains chemicals subject to TSCA Section 12b export notification, they are listed below:

<u>Chemical</u>	<u>CAS #</u>
None	NA

CERCLA (COMPREHENSIVE RESPONSE COMPENSATION, AND LIABILITY ACT)

Chemicals present in the product which could require reporting under the statute:

<u>Chemical</u>	<u>CAS #</u>
Lead	7439-92-1
Sulfuric acid	7664-93-9

SARA TITLE III (SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT)

The finished product contains chemicals subject to the reporting requirements of Section 313 of SARA Title III.

<u>Chemical</u>	<u>CAS #</u>	<u>% wt</u>
Lead	7439-92-1	65
Sulfuric acid	7664-93-9	25

CERCLA SECTION 311/312 HAZARD CATEGORIES: Note that the finished product is exempt from these regulations, but lead and sulfuric acid above the thresholds are reportable on Tier II reports.

Fire Hazard	No
Pressure Hazard	No
Reactivity Hazard	No

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Immediate Hazard	Yes (Sulfuric acid is Corrosive)
Delayed Hazard	No

Note: Sulfuric acid is listed as an Extremely Hazardous Substance.

STATE REGULATIONS (US):

California Proposition 65

The following chemicals identified to exist in the finished product as distributed into commerce are known to the State of California to cause cancer, birth defects, or other reproductive harm:

<u>Chemical</u>	<u>CAS #</u>	<u>% Wt</u>
Arsenic (as arsenic oxides)	7440-38-2	<0.1
Strong inorganic acid mists including sulfuric acid	NA	25
Lead	7439-92-1	65

California Consumer Product Volatile Organic Compound Emissions

This Product is not regulated as a Consumer Product for purposes of CARB/OTC VOC Regulations, as-sold for the intended purpose and into the industrial/Commercial supply chain.

INTERNATIONAL REGULATIONS (Non-US):

Canadian Domestic Substance List (DSL)

All ingredients remaining in the finished product as distributed into commerce are included on the Domestic Substances List.

WHMIS Classifications

Class E: Corrosive materials present at greater than 1%

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the Controlled Products Regulations.

NPRI and Ontario Regulation 127/01

This product contains the following chemicals subject to the reporting requirements of Canada NPRI +/-or Ont. Reg. 127/01:

<u>Chemical</u>	<u>CAS #</u>	<u>% Wt</u>
Lead	7439-92-1	65
Sulfuric acid	7664-93-9	25

European Inventory of Existing Commercial Chemical Substances (EINECS)

All ingredients remaining in the finished product as distributed into commerce are exempt from, or included on, the European Inventory of Existing Commercial Chemical Substances.

European Communities (EC) Hazard Classification according to directives 67/548/EEC and 1999/45/EC.

<u>R-Phrases</u>	<u>S-Phrases</u>
35, 36, 38	1/2, 26, 30, 45

Additional Information

This product may be subject to Restriction of Hazardous Substances (RoHS) regulations in Europe and China, or may be regulated under additional regulations and laws not identified above, such as for uses other than described or as-designed/as-intended by the manufacturer, or for distribution into specific domestic destinations.

SECTION 16: OTHER INFORMATION

OTHER INFORMATION:

Distribution into Quebec to follow Canadian Controlled Product Regulations (CPR) 24(1) and 24(2).

Distribution into the EU to follow applicable Directives to the Use, Import/Export of the product as-sold.

SOURCES OF INFORMATION:

International Agency for Research on Cancer (1987), *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Overall Evaluations of Carcinogenicity: An updating of IARC Monographs Volumes 1-42, Supplement 7, Lyon, France.*

Ontario Ministry of Labour Regulation 654/86. Regulations Respecting Exposure to Chemical or Biological Agents.

RTECS – Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health.

MSDS/SDS PREPARATION INFORMATION:

DATE OF ISSUE: **15 December 2011**

SUPERCEDES: **3 May 2011**

DISCLAIMER:

This Material Safety Data Sheet is based upon information and sources available at the time of preparation or revision date.

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END

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