LIMBACH

Flugmotoren

Installation Manual
L 1700
L 2000
and
L 2400 Series

This Manual was approved according to the procedures
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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Title

The title of this manual is:

Installation Manual for the LIMBACH L 1700, L 2000 and L 2400 Series Engines.

1.2 Foreword

This manual describes the requirements for the installation of the LIMBACH aircraft engines. The manual contains the mandatory requirements and also a number of recommendations and guidelines. This manual is for use by aircraft designers.

LIMBACH Flugmotoren cannot forsee all engineering aspects related to the specific aircraft installation situation. Therefore this manual is to be used as an assistance in the engine installation design. National airworthyness regulations may override or contradict the information given in this manual. In such cases you should contact LIMBACH Flugmotoren for guidance, in certain cases your aviation authorities may waive their requirements or procedures if a reasonable explanation is given.

1.3 Applicability

This manual is applicable to all engines of the following types: LIMBACH L 1700, L 2000, L 2400.

The chapters are divided up into L 2000 and series and L 2400 EF engine headings.

L 2000 and series represents all L 1700, L 2000 and L 2400 EB engines, which are air-cooled and supplied with conventional carburetors and magneto-ignition systems.

L 2400 EF is described especially because of it´s electronic engine management system with electronic ignition, fuel injection and liquid-cooled cylinder heads.

1.4 Copyright

2 MEASUREMENTS

The dimensions of the different engine series are given in the applicable installation drawings. They also contain the location and size of the engine interfaces (all dimensions are given in millimeters).

2.1 Definitions

Following an illustration indicating the cylinder designation, direction of rotation etc.

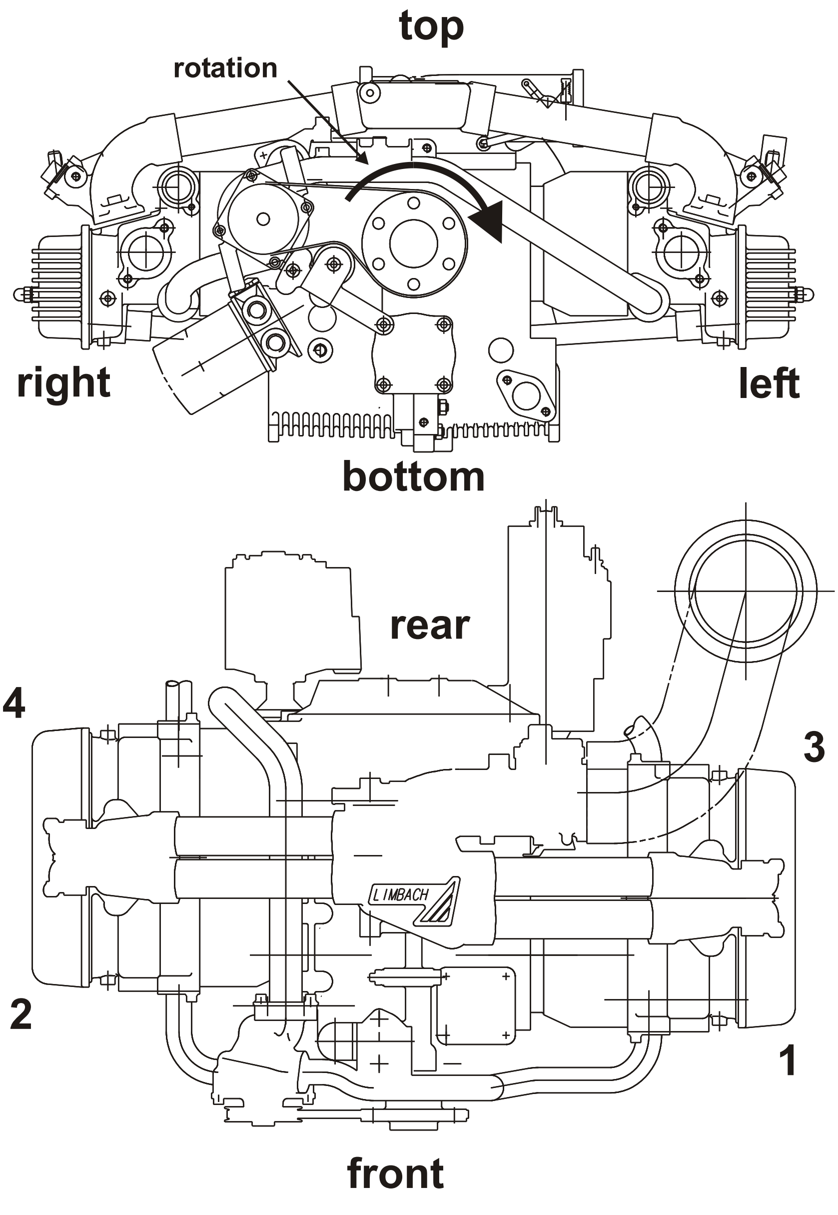

Fig.: 2-1

3 COOLING

3.1 Description

3.1.1 L 2000 and Series Engines

The L 1700, L 2000 and the L 2400 EB series engines are air cooled. For safe operation, a cowling and baffle system is required. The air that enters the inlets (A) must be guided through the finned passages of both the cylinders and the cylinder heads. The heated air then exits through the cowling exit (E). The exit opening should be approximately twice the size of the inlet. The engine requires air at approximately 1000 liters/second at a pressure drop of between 200.0 mm and 300.0 mm of water (standard atmospheric pressure). Baffles (B) must be fitted correctly to achieve the optimum cooling performance. The baffles should touch the cooling fins of the en-

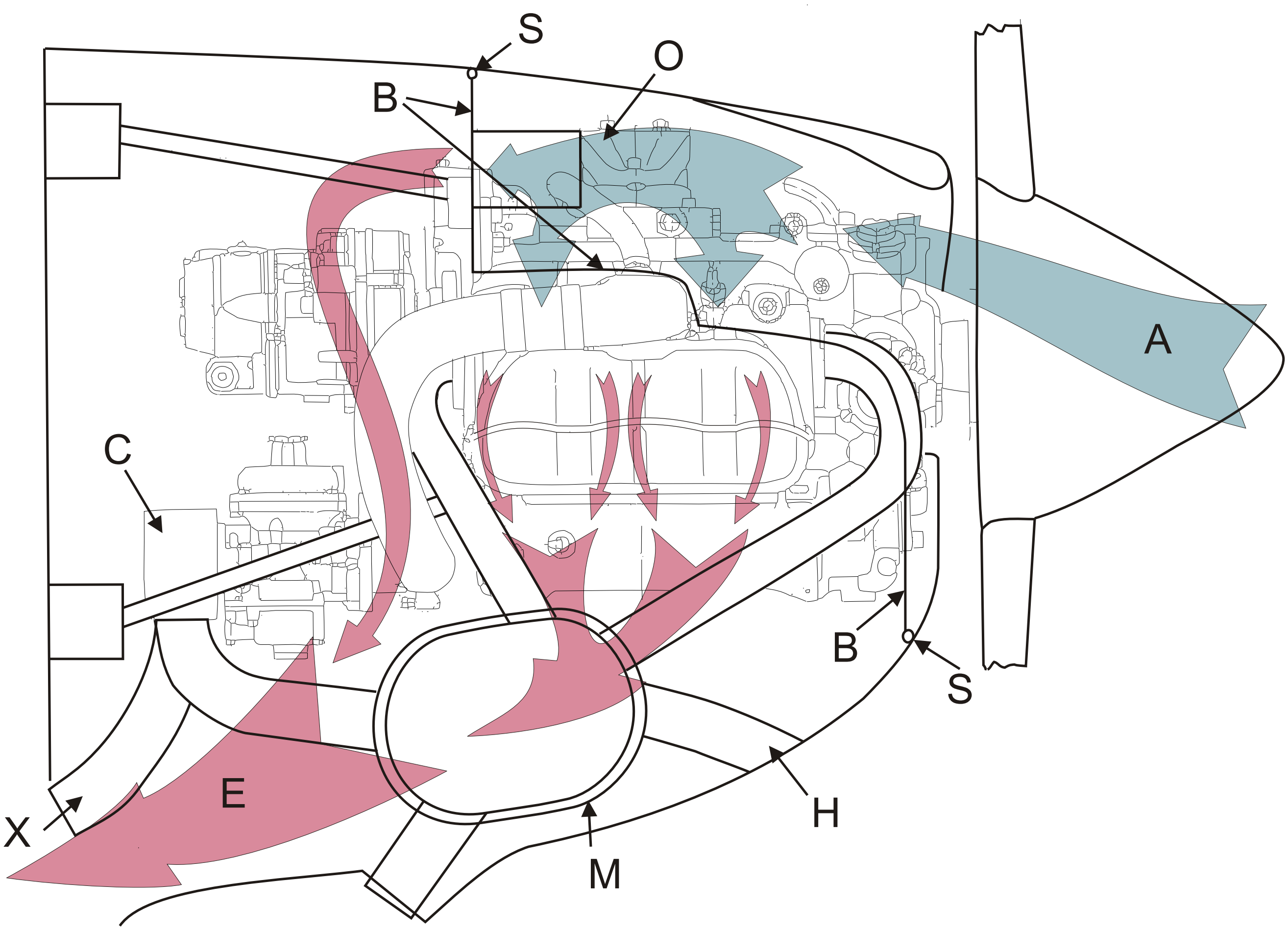

Fig.: 3-1Typical Engine Installation

gine and must be sealed (S) against the cowling and the engine. To obtain the correct fit at the propeller is more difficult but must also be achieved with care. Openings, the size of the palm of the hand, can be observed in this area which reduces the cooling performance.

The engine is designed for downdraft cooling. Do not use updraft cooling.

For pusher- and/or fuselage-installation behind cockpit it must be ensured that the inlets are not blocked due to unsymmetric flight attitude

A typical engine installation is shown in Fig. 3-1. To obtain the maximum cooling performance, the upper plenum must be as large as possible.

The shape and size of the inlet and exhaust openings must be designed not to exceed the temperature limits (refer to the operating manual) under worst case conditions (full power climb at the lowest permitted speed).

For the maximum reliability and safety, it is not recommended to exceed a cylinder-head temperature of 160° C at high-power cruise.

The engine has an oil cooler (O) which must be positioned correctly and is the responsibility of the aircraft designer. It is possible to drain the oil from the oil cooler at regular intervals. The oil cooler must have a separate duct for the cooling air. This air is directed through the chamber of the upper plenum (cold section) of the engine cowling to the oil cooler. There is also a venting outlet. To assure a sufficient oil temperature during winter operation, it could be useful to reduce the effective inlet surface of the oil cooler by using an aluminum shielding. Other changes to the fins and/or the oil cooler are not permitted.

For cabin and carburetor heating a heat muff (M) around the exhaust may be used. It also helps to cool the exhaust, which may reacht temperatures of more than 800 °C. Use ducting hose (H) to attach the heat muff to an opening in the cowling. The heated air may then be supplied to the carburetor or to the cabin. Make sure that you have a proper exit (X) to the outside in case the cabin heating is switched off and that the duct (X) does not block the cooling air exit (E)

Caution: **Use a carbon monoxide warning device to protect the crew from a defictive heating system!**

Note: The cooling system will absorb power, which is no longer available for flight propulsion. A well designed cooling system will minimize these losses and increase the flight performance and/or lower the fuel consumption.

It is very important that all of the components in the cooling system are installed carefully.

For more information see Technical Bulletin 44 in it´s current edition.

3.1.2 L 2400 EF Engine

The cooling system of the L 2400 EF engine consists of 4 different sub-systems. The general system layout is shown in Fig. 3-2:

- liquid cooled cylinder-heads
- direct air-cooled cylinders
- oil cooling
- direct air-cooled generator

The major portion (70%) of the engine heat is dissipated by the cylinder-head cooling system. The cylinders are cooled with air, the oil mainly removes the heat caused by friction from the engine (5%). **The cooling system is not designed for continuos operation at full power when the aircraft is on the ground**. During flight the flow of air increases considerably and the cooling property also increases considerably.

The cylinder head is designed so that the liquid coolant, a water/ethylene-glycol mixture, flows through the passages in the cylinder head under pressure. A pump circulates the liquid coolant through the pipes (C_O) to a radiator (R). The coolant is the returned to the coolant pump through a pipe (C_R). Cooling air (A_R)flows through the matrix of the radiator which cools the liquid cool-

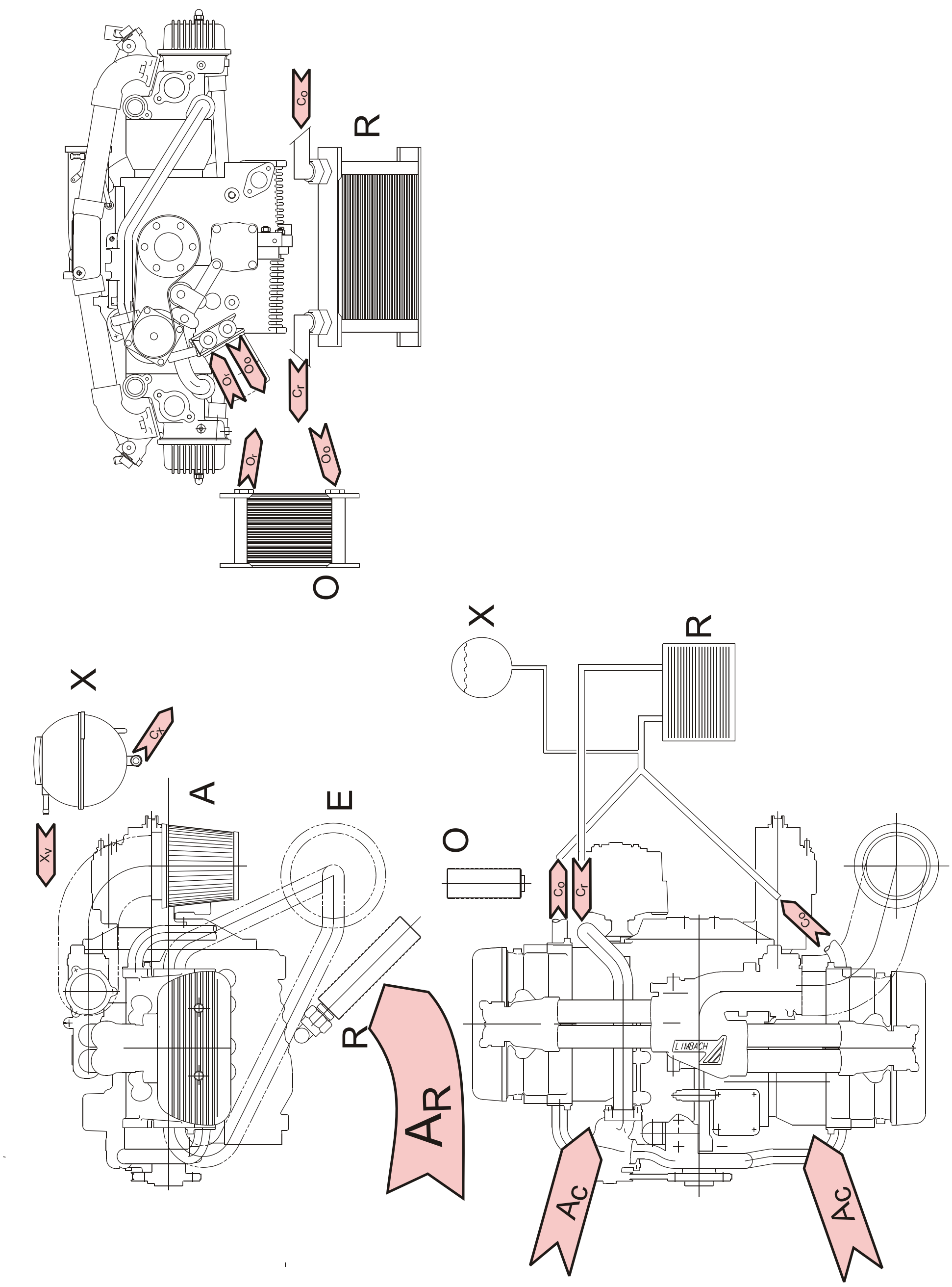

Fig.: 3-2 L 2400 EF Cooling System Layout ant. A sealed duct to the cowling is ncessary to ensure full flow through the radiator. The system has an expansion vessel (X) to receive the residue of the heated coolant. The expansion vessel has a pressure cap and a vent (X_V) to atmosphere to prevent excessive build-up of pressure.

A thermostat is not included in this system[1] because the temperature of the air-cooled cylinder wall, a major factor governing cylinder wear, is reached very quickly. To prevent the cylinder head from reaching an operating temperature which may be too low, in winter months, it is recommended that the airframe manufacturer include an aerodynamic radiator blind in the design. This will also reduce the surface drag.

The crankshaft drives the coolant pump through a pulley-wheel/belt system. A tensioning adjustment arm and jockey wheel tensions the drive-belt.

A more recent design features of cylinder-cooling is the use of units made from composite materials. This consists of two funnel shaped units connected to the front of the engine cowling. The air (A_C) flows directly to the cylinders and eliminates the requirement for the air baffles to cool the engine. This design is more efficient and it is recommended to embody this in the design of the aircraft. Use a seal of 170.163.500.000 to avoid the loss of cooling-air between the funnels and cowling.

Note The airframe manufacturer might decide to include a water-to-oil heat exchanger in preference to the separate components. They are very compact and are used in several types of automobiles. This eliminates the need for the cooling ducting which is to be found in the conventional cooling system. LIMBACH-Flugmotoren do not recommend this practice. The use of individual items is recommended for safety. If a component fails, it will not eliminate the complete system and will allow the aircraft to return safely, possibly on reduced power.

3.1.2.1 Cylinder Cooling

The cylinder cooling requires only 25% of the amount of air necessary for cooling a conventional air-cooled engine installation. Pressure cooling is required for the cylinders.

The engines are delivered with the cooling-air ducts, for cylinder cooling, already attached. The cooling air enters two inlets and is effectively directed, by the cooling-air ducts, to the surface of the cylinder. The interface of the cowling to the cooling-air ducts must be sealed.

3.1.2.2 Cylinder-Head Cooling

The cylinder-head cooling consists of the following components (Fig.:3-2):

Pos.	Item	Description
	Coolant pump	installed on engine
$C_{O,R}$	Coolant pipes	partially installed on engine missing parts are customer supplied items
$C_{O,R}$	Coolant hoses	included in the installation kit, missing parts are customer supplied items
R	Radiator (cooler)	included in the installation kit
X	Expansion vessel with pressure cap	included in the installation kit
	Thermostat	optional

1 A thermostat is optionally available on special request

The airflow to the radiator must be independent of the airflow to the cylinders, with careful design it may be possible to use a common outlet. The size of the radiator is dependent on the aerodynamic conditions such as air-speed during climb, position of installation and design of the air inlet and outlet.

The recommended sizes of the radiator are based on an air-speed of 40 m/s and a temperature difference of 60° C between the coolant and ambient air.

The size of the radiator may be reduced if there is an increase in air velocity and/or coolant temperature. However, for safety reasons, a maximum temperature of 110° C must not be exceeded.

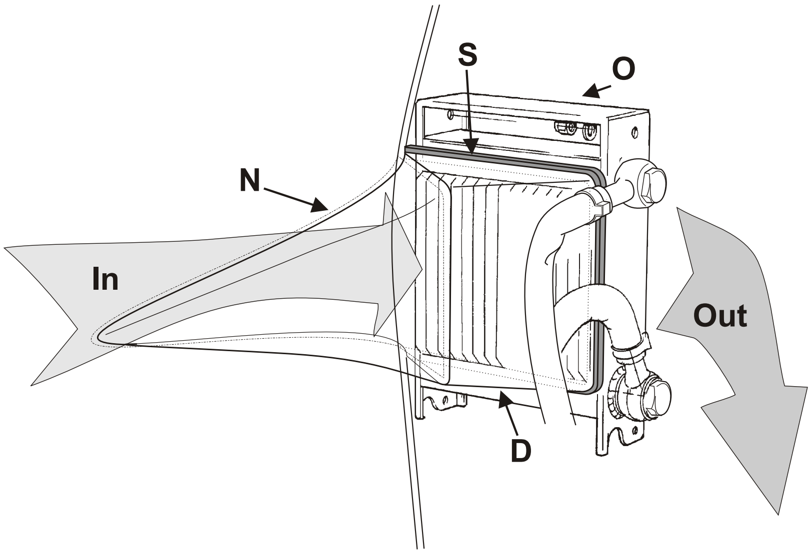

Fig.:3-3 Oil Cooler Installation L 2400 EF (Sample)

The pipes for the cooling water have a diameter of 25 mm and the mixture is 50% glycol for frost and corrosion protection. There are two bleed lines from the outlets from the engine to the expansion vessel. The angle of installation of the radiator is 45° and is installed on the brackets of the engine mounts. Flexible hoses permit the engine to move in relation to the engine mounts (engine is installed in rubber anti-vibration blocks). Make sure that the outlet for the cooling air is of an adequate size . Install the expansion vessel at the highest point (for bleeding).

3.1.2.3 Oil Cooling

Oil cooling (Fig.: 3-3) requires another radiator or heat exchanger, which can be slightly larger than required because of the thermostat. The oil cooler is delivered within the installation kit.

The oil cooler may be attached directly to the cowling and the cooling air is provided through an NACA inlet (N) and a Duct (D) to the oil cooler (O). The cooler must be sealed against the duct with an elastic seal (S) to prevent an air bleed to the inside of the engine cowling. The air bleed would cause a disturbance of the pressure differential which is used to operate the air-based portion of the cooling system. The warm air exiting from the cooler must pass through the main cooling air exit. Be sure to dimension it accordingly.

Note: The duct (D) must also be sealed towards the cowling. Keep in mind that the installation situation may change with manufacturing tolerances which may be very large with all dependencies considered. Also consider that the enduser may not always fit the cowling correctly and that the sealing should function in such cases also. Inspection of the seals should be included as an item in your maintanance documentation.

3.1.2.4 Technical Data

Coolant flow (liquid cooling)	approx. 0.1 m^3/min. @3000 rpm
Max. coolant temperature	110° C
Size of radiator	approx. 4,5 dm^2
Air-speed ahead of the radiator	approx. 40 m/s
Max. pressure in the cooling system	1.2 bar
Air flow over cylinders	approx. 0.2 m^3/s / 0.17 kg/s
Size of oil cooler	approx. 2.0 dm^2

3.1.2.5 Generator Cooling

On the rear of the generator is a cooling cap to prevent overheating of the diode plate. A wire reinforced hose of diameter 25 mm supplies pre-cooling air to the oil cooler at the NACA inlet.

4 FUEL SYSTEM

4.1 Requirements

The fuel system has to be designed for all types of fuel as given in the operating manual and there should also be a good chemical resistance to cleaning materials. An hazardous operating condition may occur when fuel tanks are used which are made of composite material and observe the surface sealing and also the adhesion. New lead-free fuels contain an alcoholic dissolvent. Both a fuel filter and a water trap should be provided at a suitable location. No particles larger than 7-10 µm must be allowed to pass through the filter.

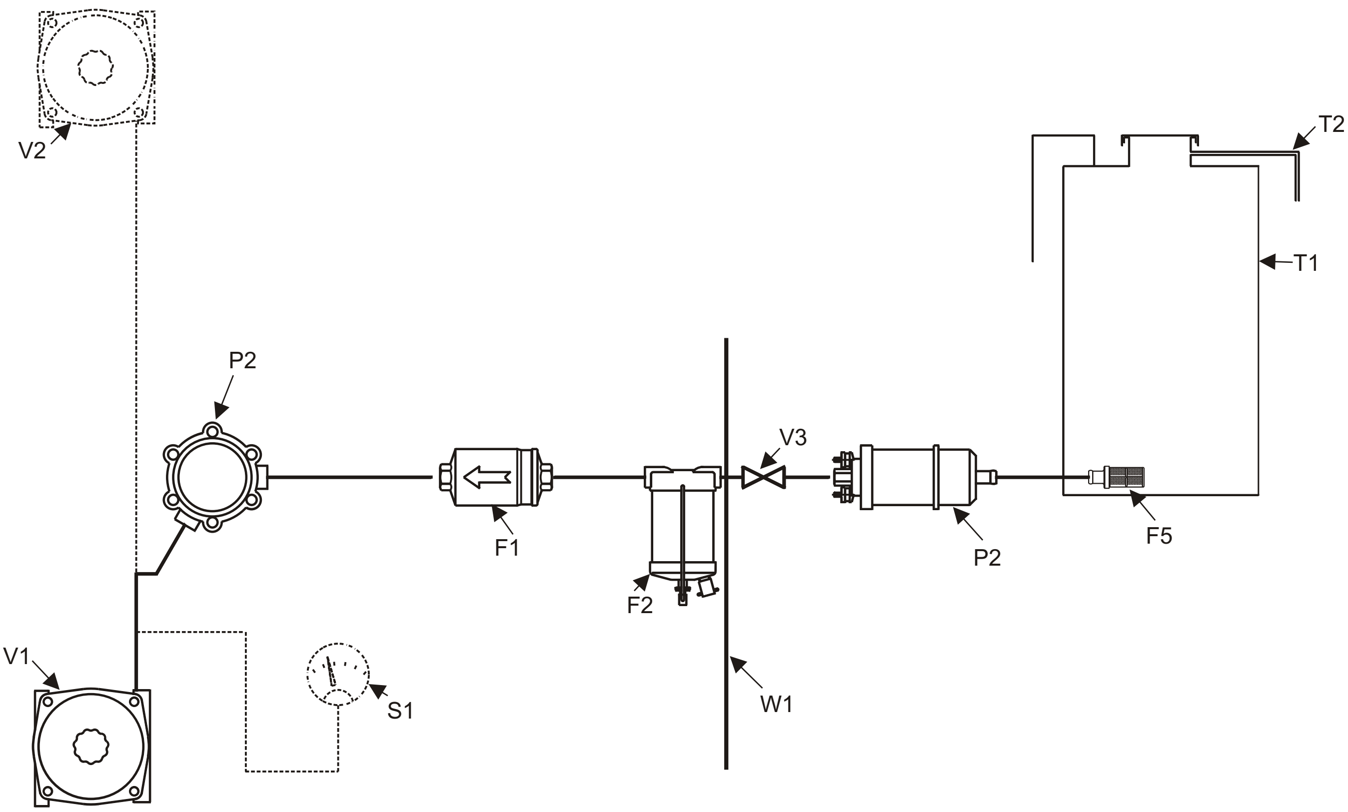

Fig. 4-1 Fuel System Diagram, Engines with Carburetors

Depending on the design of the fuel system and the ambient temperature, vapor locks may occur. These create a severe power loss. In some aircraft it may be possible that the pilot may not observe any indication of this during taxiing and the take-off run. The operating manual of the aircraft must contain an indication of this fact. The probability of vapor locks is minimized if the instructions on the connection diagram are followed. The electrical fuel pump must be placed at the coolest position in the system. In order to reduce the fire hazard, only minimum quantity of fuel is to be contained forward of the firewall.

4.1.1 L 2000 Series Engines

The filter must have a capacity of between 0.15 liters and 0.25 liters. A suitable filter is available under the part number 201.090.015.000.

The L 2000 series engines are provided with a positive displacement mechanical pump which is sufficient for normal use. For additional safety, an electrical fuel pump should be connected in line to the mechanical pump (diagram). The electrical pump is mandatory if MOGAS fuel is used.

4.1.1.1 Connection Diagram

Fig. 4-1 illustrates a sample fuel system. The layout may vary with aircraft and national airworthiness requirements. The designations of the diagram symbols are as follows:

F1	Fuel filter
F2	Water trap
F5	Tank filter
P1	Mechanical fuel pump
P2	Electrical fuel pump
T1	Fuel tank
T2	Tank vent
S1	Fuel pressure indicator (optional)
V1	Carburetor
V2	Carburetor (only twin carb models)
V3	Fuel cock
W1	Firewall

4.1.1.2 Carburetor System

LIMBACH engines in general are equipped with constant depression carburetors. Therefore the pressure of the intake-air must be at the same level as the air pressure for the float chambers ventilation and for a working altitude correction. Never use a direct pressure air supply for the intake because this would give a very inconstantly lean mix ratio. A carburetor heating system is recommended to prevent carburetor icing (Fig. 4-2 and Fig. 4-3). Please note

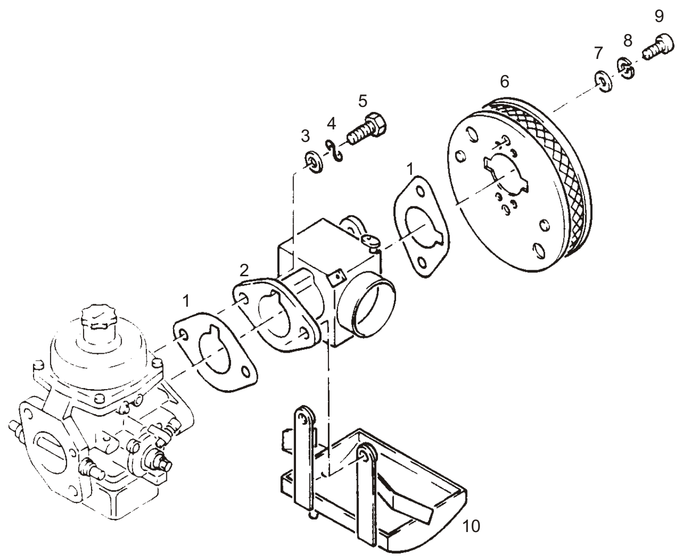

Fig.4-2 Sample Carburetor Preheat System L 2000 EA (Single Carburetor) series

the fuel tray (item 10) which is located below the carburetor to prevent fuel from dripping onto hot engine components.

Position of the notch in gasket (1) is also very important to ensure the function of the carburetor. Check the air filter flange of the carburetor and make sure that the openings are not covered with the gasket.

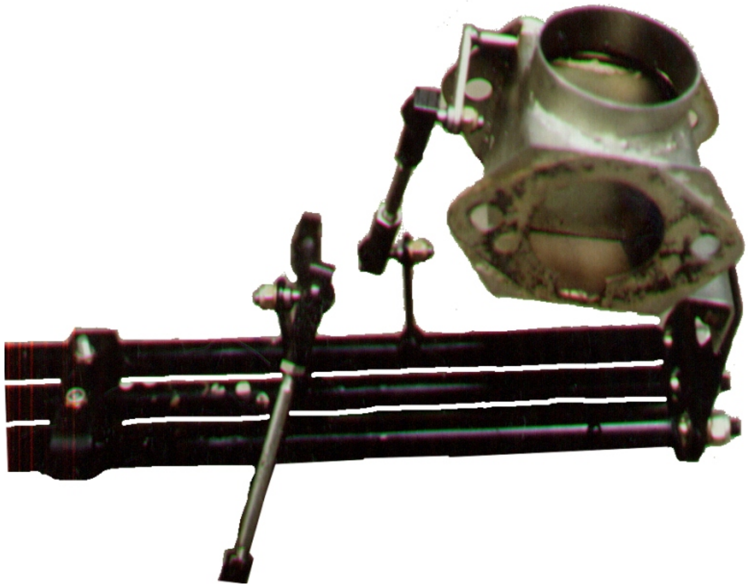

Fig. 4-3 Sample Carburetor Preheat System L 2000 EB1AA (Twin Carburetor) Series

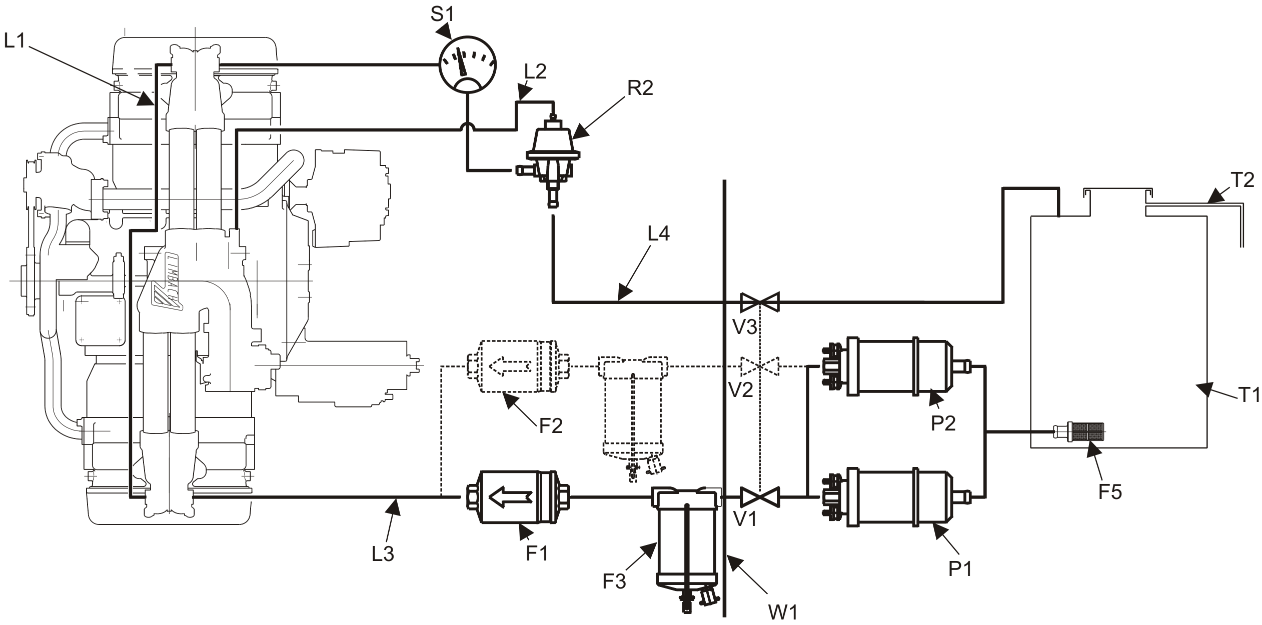

Fig. 4-4 Fuel System Schematic L 2400 EF

4.1.2 L 2400 EF Engine

4.1.2.1 Components

The fuel pipes must be so routed as to avoid heating of the fuel. The L 2400 EF engine has electric fuel pumps which provide the required injection pressure and the delivery output is approximately 100 l/h. This is well above the maximum consumption of 30 l/h. The pressure regulator controls the injection pressure. Fuel not injected into the cylinders flows from the pressure regulator back into the tank (loop circuit). The fuel system, downstream of the pumps, operates at a pressure of 2.5 bar. The material of the fuel lines, internal diameter 6.0-8.0 mm, is to be compatible with the type of fuel used. Suitable fuel lines are available on request.

4.1.2.2 Description

Fuel is supplied to the injection nozzles (F1-F4) by a loop circuit which prevents the formation of gas bubbles. The tank(s) (T1) also provides the function of the radiator[1]. The fuel flows from the tanks to the active pump (P1 or P2), from the pump to the filters (F1-F4), to the injection nozzles 4, 2, 1 and 3, from the injection nozzles to the pressure sensor (S1) and then to the pressure regu-

1 The fuel tank should have some extra volume to allow for expansion of the fuel and to provide some extra space for separation of air bubbles.

lator (R2). The unused fuel flows back into the tanks. The electric driven pumps, arranged in parallel and the separator(s) (F3, F4), are to be located at the lowest possible position in the fuel system (Fig. 4-4). The fuel lines uses must be pressure resistant to a design pressure of 3 bar and to a limit pressure of min. 6 bar. They must be protected with fire resistant sleeves. Also the fuel lines must be chemically resistant against aviation and automotive fuel, alcohol (methanol) and engine oil.

Item	Component	Remark	Position
F1-F4	Fuel injection		Engine
T1	Tank		Airframe/wings
T2	Tank vent		
F1, F2	Filter	7.0 um, with replacement and inspection facility	Firewall / airframe
F3, F4	Water separator(s)	main fuel/feed auxiliary system if specified	firewall
F5	Tank Filter		Tank
L1	Fuel line	Crossover line to cylinder banks	Engine
L2	Fuel line	Return to fuel pressure regulator	Engine to firewall
L3	Fuel line	Pressure line from pump(s)	Firewall/engine
P1, P2	Fuel pumps	electrically driven; main and auxiliary system	Firewall / airframe
S1	Fuel pressure sensor	connect between cross-over line and pressure regulator.	firewall
V1-V3	Shut-off valve(s)	main fuel/feed auxiliary and return lines if specified	Airframe
R2	Pressure regulator	connect manifold pressure, cross-over and return line	firewall

4.2 Airfilter

An air filter (A) (see Fig.:3-2) should be used to protect the engine from dust and dirt. The air filter duct has been optimized for the engine and should not be changed, because the power might be reduced. The air filter must be provided with cool air from the outside. An enclosure for the air filter that is attached to the cowling has proven to be practical. A drain vent in the air filter enclosure provides protection from water accumulation in the cell of the air filter. An internal vane prevents the ingress of water.

5 ELECTRICAL SYSTEM

5.1 Description

The power output of the starter largely depends on both the size of the battery and the cross-section of the cable. The starter will draw a current of up to 300A.

Caution: **Be aware of a possible fire hazard when installing the starter cable.**

5.2 L 2000 Series Engines

The L 2000 series engines have a 12V electrical system for both the starter and the alternator, a 24 V System is available on request. Observe the wiring diagram.

Recommended figures for the battery capacity are 12V/28Ah and a cross-section for the starter cable 16mm².

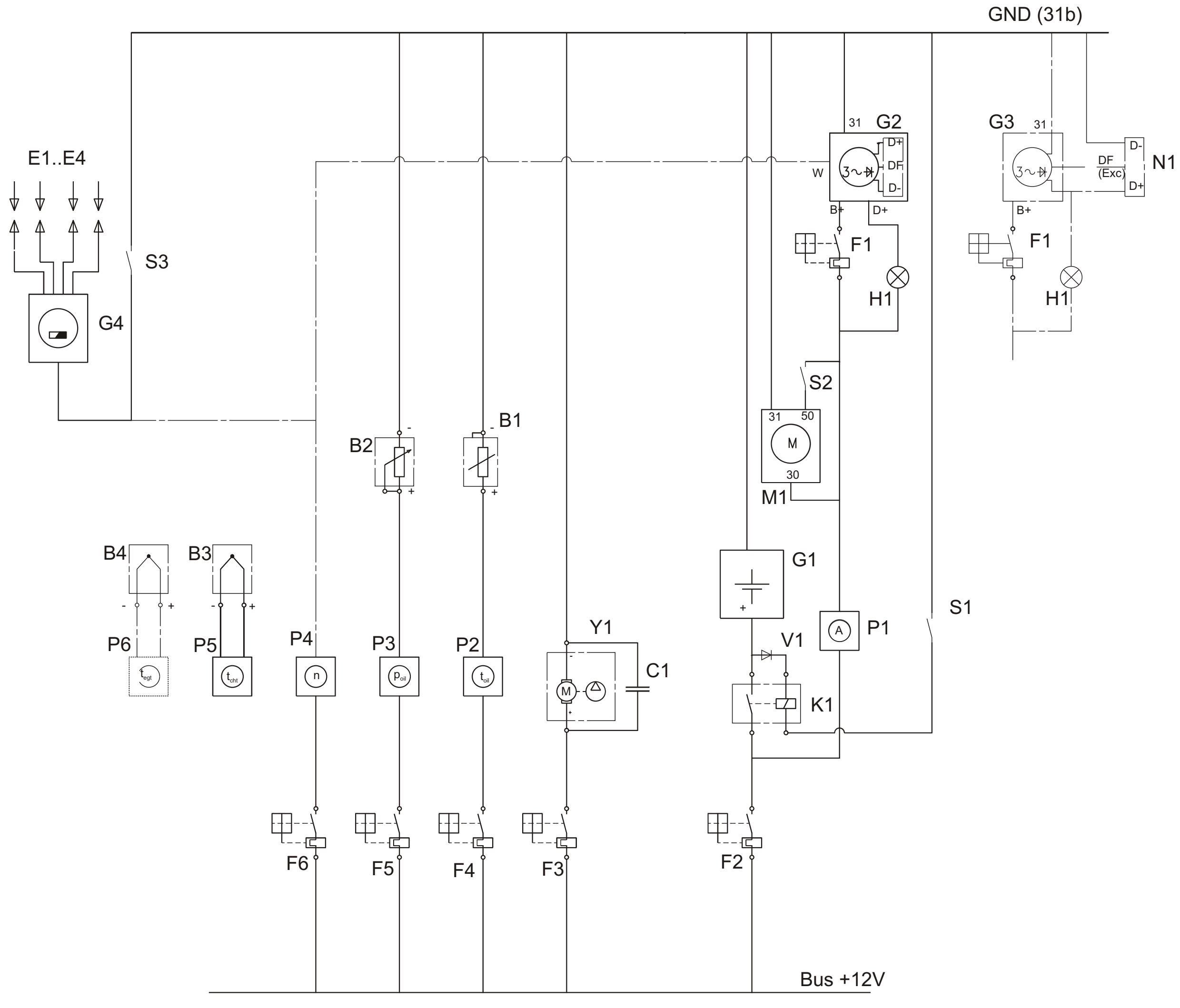

Fig. 5-1 Sample Wiring Diagram for L 2000 Series

According to your installation, these figures may vary considerably.

A ground cable from the engine to the battery is required. It should have at least the same cross section as the starter cable and should be attached to one of the starter mounting bolts.

Warning: **If the magneto switch is be set to the "ON" position (for example circuit testing) beware of the "Hot-Engine"condition especially if the propeller is attached. The battery must not discharge with the magneto switch in the "ON" position.**

5.3 L 2400 EF Engine

5.3.1 Description

The L 2400 EF engine has a 12V electrical system for the engine electrics, the starter, the pumps and the generator. The engine is equipped with an electronic engine management system that provides full control of the fuel and ignition requirements of the engine throughout the complete operational envelope. Mixture control, due to the ambient conditions, is automatic.

The information required to calculate the fuel flow and ignition advance is given in two basic tables with 16 x 16 fields. This gives a total of 256 individual values for each of the two functions. Engine speed and throttle angle are used to address the information given in the tables. Engine requirements for operating conditions that do not exactly correspond to the table entries are interpolated. Additional inputs give information on air temperature, air pressure and engine temperature. They are used to adjust the values in the basic table to the requirements for non-standard environmental conditions. The Engine Control Unit (ECU) is the electronic brain.

Warning: **Function of the engine management system is dependent on the availability of electrical power.**

Unlike conventional engines with magnetos, the L 2400 EF engine will not function without a 12V power source. To provide operational behavior similar to the conventional engines that most pilots may be familiar with, a back-up system is essential. This is provided by the emergency switch and the relay box (MCU). It should ensure a supply of the electrical power for the engine function for a minimum period of twenty minutes after the loss of power from the main electrical system.

The emergency switch is included in the circuit in case the fuel pump or a sensor cases to function. In the emergency operational mode, the second fuel pump replaces the previously active pump, the second speed sensor replaces the previously active speed sensor. The sensors revert to a permanently set resistance. The engine can be started with the emergency switch in the "Emergency operation" position, providing that the main switch is in the "ON" position and the main battery functions correctly. The housing has a diameter of 53.0 mm. The emergency switch does not influence the electrical power supply/period of operation.

The relay box has the function to supply the engine with electrical power from the main battery, generator and the emergency battery. The nominal current is 12V. There is a 9 Amp. consumption for engine operation. Because the operation of the engine is dependent on the functional operation of the electrical power supply, the emergency battery and appropriate switching inside the relay-box (MCU) is necessary. No electrical power flows from the emergency battery into the aircraft network but the battery can be continually charged. The generator provides the system with 13.5-14.0V.

5.3.2 Connection of the Engine Electrics

5.3.2.1 Mounting of the ECU and wiring loom

The ECU should be mounted with shock mounts. For example 1 Barrymount GE 21-03-05 may be used at the backside and 2 Flex-Loc Q-6 at the front.

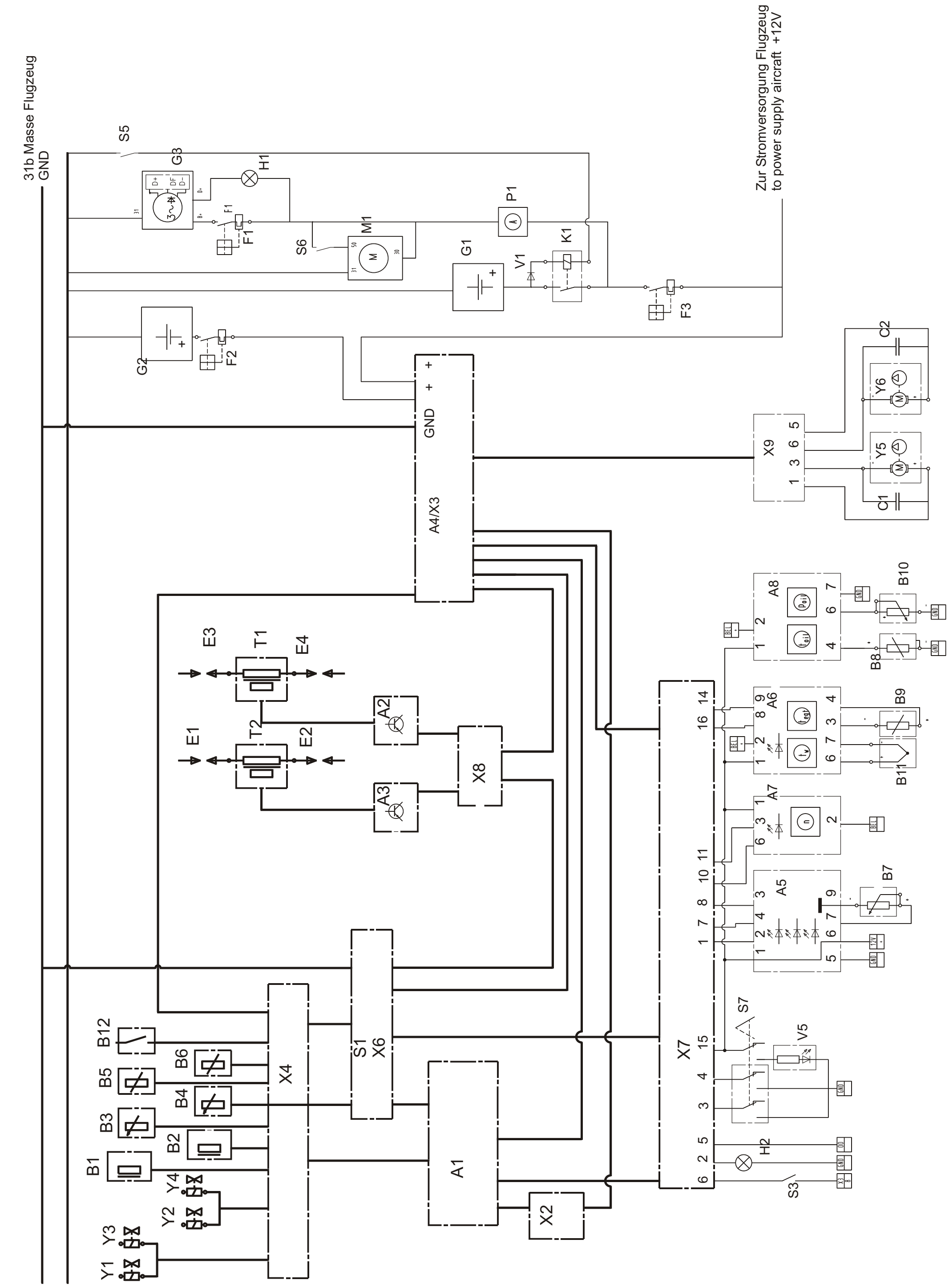

Fig. 5-2 Block Diagram L 2400 EF Electrical System

Access thru the firewall is required, for the plugs and the flanges X4 and X8 to lay the ECU cable loom. The plugs and the flanges X4 and X8 are attached to the firewall. Each connector needs 4 bolts M4x15 mm, washers and nuts.

5.3.2.2 Connection of the wiring loom

The cables for the engine are divided into three cable looms:

- cable loom, ECU (in cockpit)
- cable loom, engine
- cable loom, ignition.

Connect the ground connection for the electro-magnetic shield (EMS). The cable loom, engine, is connected to the cable loom, ECU, at the firewall. The cable loom has a pronounced hang near X4 to prevent water, due to condensation, from running into the plug (“water sack“). The subsequent routing of the cable loom must be made such, that it is not parallel to the cable loom, ignition. Connect the cable loom to the appropriate sensors, ignition nozzles and the water-loss contact on the expansion vessel. Connect the ground connection for the EMS. The cable loom, ignition, is to be assembled in accordance with the designations.

The ECU, mounted on the instrument panel on the console, is connected to the plug X1. There must be no collection of hot air or heating.

The cable looms, MCU and ECU, should be easily detachable. The cable loom, ECU, is connected to the emergency switch, which is mounted in the instrument panel, by the plug X6. The fuel pumps are connected by the plug X9.

A reliable ON/OFF switch for the engine electrical power is mounted in the instrument panel and is connected by the contacts provided to the plug X7. The LED’s for the status of the emergency are connected to the plug X7 if instrument 250.215.025 000 is not used. The plug X7 also provides further outputs for the instruments.

5.3.2.3 Connection of the Relay-box (MCU)

The electrical power for the engine electrics is supplied thru the relay-box (MCU).

- (+)emergency batt. terminal to the emergency battery
- (+)main batt. terminal to the main relay K1 and main circuit breaker FH
- (-) terminal = GND to (-) of the main battery

Keep the cables as short as possible. The fuses for the engine are in the relay-box (MCU).

5.3.2.4 MCU- test

It is possible to carry out the following test for correct MCU-connection:

- Set the meter (e.g. Voltkraft M3850D) to diode test +=
- Attach the negative (-) terminal on the meter to the emergency battery (+), the positive (+) terminal on the meter to the main battery (+)
  =>Display: approximately 200mV
- Attach the positive (+) terminal on the meter to the emergency battery (+), the negative (-) terminal on the meter to the main battery (+)
  =>No display, overload (OL)

5.3.2.5 MCU and emergency battery test

A functional check of the emergency battery and MCU can be carried out by:

- disconnecting the Generator before starting the engine
- switching off the main switch whilst the engine is running then
- the engine has to keep on running (20 minutes)

The emergency battery now supplies the relay box with the electrical power for engine operation. The warning lamp “Emergency battery discharging” illuminates.

5.3.2.6 ECU (P/N 250.127.560.000)

Starting Dec 2013 all new engines will be equipped with a new, more compact ECU also having additional features such as active control for the turbocharger, integrated ignition drivers and CAN-Bus communication as an option. The main connection for manifold pressure (MAP) is now made directly to the ECU.

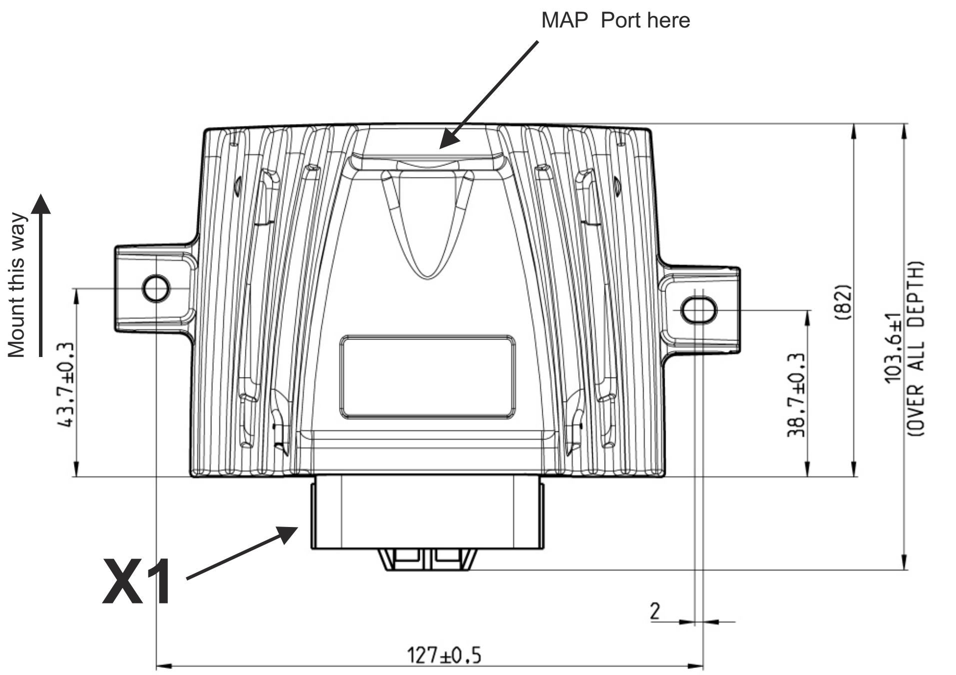

Fig.:5-3 ECU P/N 250.127.560.000

5.3.3 Engine Instruments

5.3.3.1 Engine Monitoring System

Limbach Flugmotoren offers the option of engine monitoring system. This display for engine data offers many advantages versus the now obsolete dial instruments.

The engine monitoring systen can display aircraft data in addition to the engine parameters.

For installation and operation please refer to the separate handbooks

Note: The instrument is certified as a part of a Limbach aircraft engine. The certification is not valid if the instrument is installed on engines of other manufacturers.

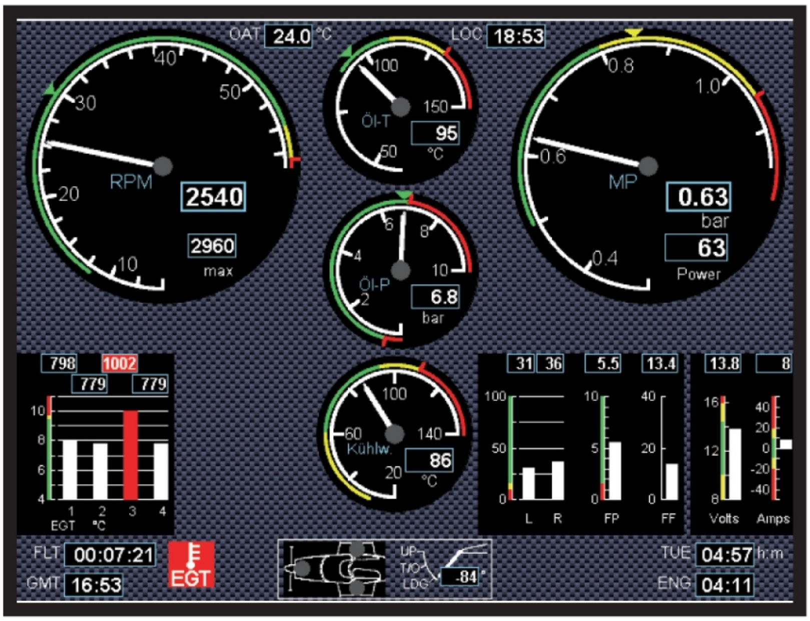

Fig.: 5-4 Symbolic Illustration of the engine monitoring display

5.3.4 Obsolete Instruments

Instruments with Dial indicators are no longer supported by Limbach

A selection of instruments are available. Sensors for the oil temperature, oil pressure, water temperature and EGT are mounted on the engine. The appropriate cables are to be routed. Connection is to be in accordance with the instructions of the equipment manufacturer. Certain instruments will be connected to the plug X7. Optional instruments are:

Function	Diameter	Part No.
Oil temperature Oil pressure combination instrument	57 mm	250.215.010.000 (obsolete)
Oil temperature	53 mm	170.215.100.000 (obsolete)
Oil-Pressure	53 mm	170.215.110.000 (obsolete)
Water temperature, EGT, Water-loss warning lamp combination instrument	57 mm	250.215.020.000 (obsolete)
Status Indicator (engine-hour counter and warning-LED´s: fuel-pressure, discharging emergency-batt. charging emergency-batt.)	57 mm	250.215.025.000 (obsolete)
RPM-indicator, (operating with the engine´s inductive sensors)	80 mm	250.215.002.000 (obsolete)

RPM-indicator, type “W“ from VDO	80 mm	250.215.002.000 (obsolete)

5.3.4.1 Instrument calibration

Calibration of EGT and water temperature (250.215.020.000 obsolete)

EGT instrument calibration “K“ (turn RFSD):

Temperature	Calibration voltage
800° C	32,7 mV
700° C	29.1 mV
500° C	20,6 mV

Water temperature: Adjust L"0" at 30°C, LFSD at 90°C with sensor in warm water

Calibration of oil pressure and oil temperature (250.215.010.000 obsolete)

Oil pressure: Adjust R"0" for 0 bar with 10 ohm, RFSD for 6 bar with 115 ohm

Oil temperature: Adjust L"0" at 50°C, LFSD at 90°C with sensor in warm water

Calibration of RPM-indicator (250.215.001.000 obsolete)

Adjust the “0” point first. Then run up engine to approximately 2500 - 3000 rpm, measure the propeller rpm with a calibrated optical tachometer and adjust the “R” screw accordingly.

5.3.4.2 Connection of RPM indicatorwith 9-Pin connector (obsolete)

RPM indicator (250.215.001.000)

Pin	Destination

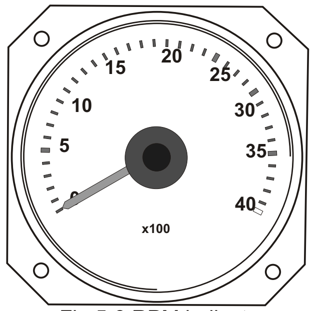

Fig.5-8 RPM indicator 250.215.001.000

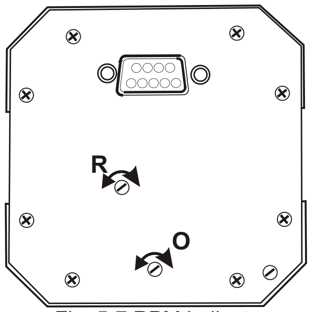

Fig. 5-7 RPM indicator 250.215.001.000.000 rear view

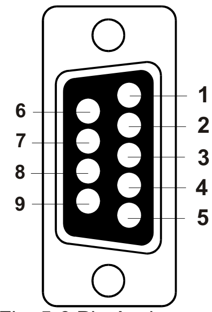

Fig. 5-6 Pin Assignments 9-Pin Connector

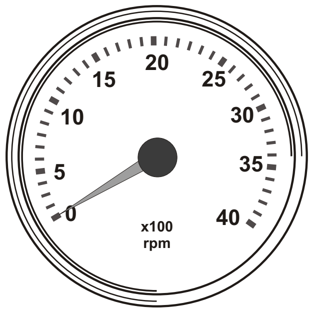

Fig.: 5-5 RPM Indicator “W”

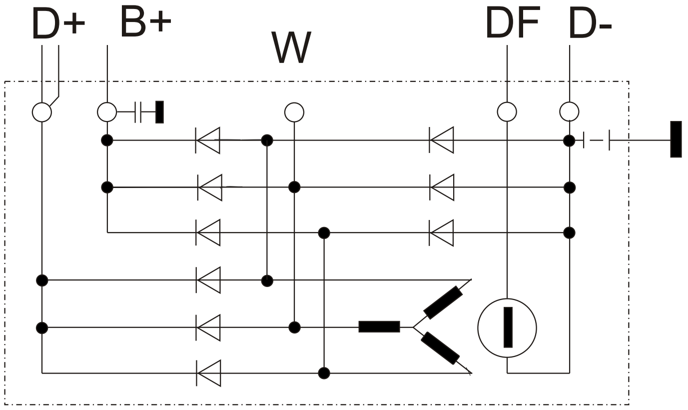

Fig.: 5-13 Internal Diagram of Generator with RPM-pickup “W”

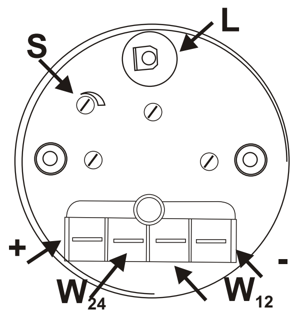

Fig.: 5-12 RPM Indicator “W” Connector Side

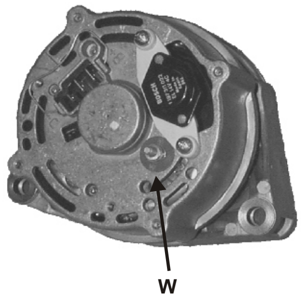

Fig.:5-11 Generator with RPM-pickup “W”

1	+12 V
2	+12 V
3	Input Sensor+
6	Input Sensor-, GND

5.3.4.3 Connection of RPM-Indicator with Generator-pickup (obsolete)

Alternatively an RPM-indicator with Generator-pickup may be used (Fig.: 5-5). Check wether the Generator has the appropriate connector “W” (Fig.:5-11).

The pickup “W” on the generator is connected with the appropriate terminal on the RPM indicator (Fig.:5-12). Note the different connectors for the different supply voltages.

After installation, the instrument must be calibrated. Measure the propeller rpm with an optical tachometer at approximately 2/3 max engine rpm and adjust the screw “S”.

Fig.: 5-9 Oil Pressure and

5.3.4.4 Oil pressure and oil temperature

(250.215.010.000)

Pin	Destination
1	+12 V
2	+12 V (Light)
3	(GND)
4	Sensor, temperature, VDO
5	(GND)

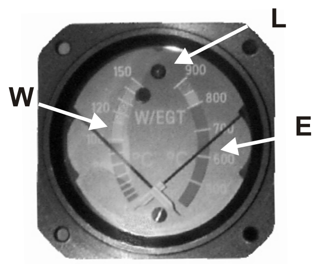

Fig.:5-10 EGT, Coolant Temp. and Coolant Level Indicator

Pin	Destination
6	Sensor, pressure 0-10 bar, VDO
7	GND

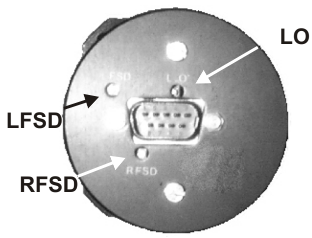

Fig.:5-15 Rear View Dual Indicator Instruments

5.3.4.5 EGT, coolant temperature and coolant level warning lamp (obsolete)

(250.215.020.000)

Pin	Destination
1	+12 V
2	+12 V (Light)
3	GND, water temp. sensor -
4	Sensor, water-temperature +
5	Sensor, EGT -
6	Sensor, EGT +
7	GND,
8	LED -
9	LED +

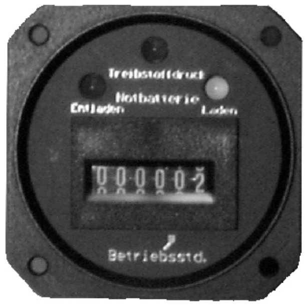

Fig.: 5-14 Multi- Status Indicator and Hour meter

5.3.4.6 Status Indicator

(250.215.025.000)

Pin	Destination
1	X7/15 (+12 V)
2	X7/1 (Counter)
3	X7/8 (Discharge)
4	X7/7 (Charge)
5	X7/13 (GND)
6	X7/15 (+12 V)
7	Sensor, fuel pressure +
9	Sensor, fuel pressure GND

5.3.5 Fuel Pumps

The electrically driven fuel pumps are connected to the plug X9.
Drill the plugs to accommodate AWG 16.

Connector / Pin	Destination
X9 / 1	Pump 1 (+)
X9 / 3	Pump 1 (-)
X9 / 4	Pump 2 (+)
X9 / 6	Pump 2 (-)

5.3.6 Connections for the Instruments/Panel

The cockpit instruments are connected to plug X7 on the wiring harness

5.3.6.1 ECU (P/N 250.127.400.000 and 250.127.405.000)

Connector / Pin	Destination	Comment	Instrument P/N
X7 / 1	engine-hour counter		250.215.025.000
X7 / 6	switch (S3), then to GND	engine electrics ON/OFF)	
X7 / 7	yellow LED+	emergency batt. charging	250.215.025.000
X7 / 8	red LED+	emergency batt. discharging	250.215.025.000
X7 / 10	RPM-indicator		250.215.001.000
X7 / 11	RPM-indicator		250.215.001.000
X7 / 13	instruments	GND, only for instruments	
X7 / 14	LED- water-loss-lamp		250.215.010.000
X7 / 15	instruments	+12V for the instruments	
X7 / 16	LED+ water-loss lamp		250 215 010 000

5.3.6.2 ECU (P/N 250.127.560.000)

Connector / Pin	Destination	Comment	Instrument P/N
X7 / 1	signal coolant temperature		
X7 / 2	manifold pressure		
X7 / 3	power supply manifold pressure		
X7 / 4	signal, oil pressure		

Connector / Pin	Destination	Comment	Instrument P/N
X7 / 5	signal, temperature oil		
X7 / 7	signal, low oil pressure	warning light	
X7 / 8	signal battery charging		
X7 / 9	signal battery discharging		
X7 / 12	signal tachometer		
X7 / 13	control signal emergency mode		
X7 / 14	signal emergency mode on	warning light	
X7 / 15	ground emergency mode on		
X7 / 16	ground, sensors		
X7 / 21	low coolant level	warning light	
X7 / 22	ground coolant level		
X7 / 23	CAN-Bus H		
X7 / 24	CAN-Bus L		
X7 / 27	ground, signal		
X7 / 28	signal lambda sensor	only for service engineers	
X7 / 31	N/C		
X7 / 34	exhaust gas temp +	thermocouple type K	
X7 / 35	exhaust gas temp -	thermocouple type K	
X7 / 37	fuel pressure 2	optional near tank[1]	

5.3.7 Ignition System

5.3.7.1 L 2400 EF / ET engines

The ignition system consists of:

- 2 ignition coils
- 2 ignition modules
- 1 support
- 4 ignition leads.

The support, with the assembled coils and modules, is attached to the firewall (heat conductive). If possible, the installation area should be in a cool region, maximum ambient temperature 80° C.

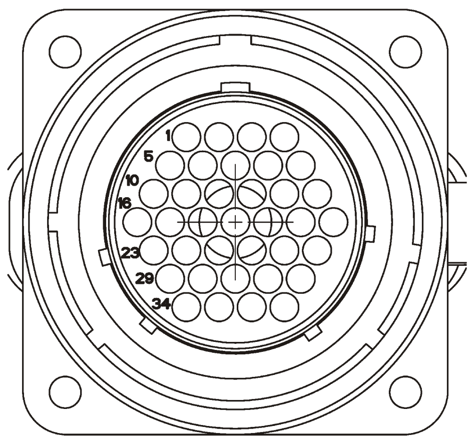

Fig.:5-16 Contact layout connector X7 ECU P/N 250.127.560.000

1 Fuel pressure sensor must be grounded with an extra wire!

Do not route the ignition leads parallel to the electrical cables.

5.3.7.2 L 2400 DF / DT / DX engines

The ignition system consists of:

- 4 ignition coils
- 4 ignition modules (ECU's 250.127.400.000 and 250.127.405.000 only)
- 2 support
- 8 ignition leads.

The support, with the assembled coils and modules, is attached to the firewall (heat conductive). If possible, the installation area should be in a cool region, maximum ambient temperature 80° C.

Engines equipped with P/N 250.127.560.000 ECU's do not require separate ignition modules.

Do not route the ignition leads parallel to the electrical cables.

5.4 Requirements

5.4.1 L 2000 Series Engines

BILL OF MATERIALS FOR THE WIRING DIAGRAM

Sign	Description	Position	Part No.
B1	Sender, oil temperature	attached to the engine	
B2	Sender, oil pressure	attached to the engine	
B3	Sender, fuel quantity -	selection of the designer	selection of the designer
B4 (B5 -B7)	Sender, CHT	cylinder head	170.215.010.000
E1-E4	Spark plug	attached to engine	
F1	Main circuit breaker (25A)	ETA 2-5700-K12 25A or	ETA 2-5700-K12-55A
F2	Gen. circuit breaker (20A)	ETA-2-5700-K12-20A or	ETA 2-5700-K12-50A
F3-F8	Circuit breaker	cockpit	ETA 2-5700-K12-5A
G1	Battery 12V-28Ah (min.)	firewall / airframe	selection of the designer
G2	Alternator 30A or 55A	attached to the engine	
G4	Magneto	attached to the engine	
H1	Indicator light	cockpit	selection of the designer
M1	Starter motor	attached to the engine	
P1	Indicator lamp	cockpit	170.215.120.000
P2	Indicator, oil temperature	cockpit	170.215.100.000
P3	Indicator, oil pressure	cockpit	170.215.110.000

Sign	Description	Position	Part No.
P4	Indicator, fuel quantity	cockpit	selection of the designer
P5	Indicator, engine speed	only if electr. tacho. spec.	201.215.001.000
P6	Indicator CHT	cockpit	170.215.001.000
S1	Switch, main	cockpit	selection of the designer
S2	Button, starter	cockpit	selection of the designer
S3	Switch, fuel pump	cockpit	selection of the designer
S4	Switch, ignition	cockpit	selection of the designer
S5	Switch, 4 position CHT	cockpit	170.215.015.000
T1	Magneto	attached to the engine	
Y1	Fuel pump, electric		170.090.010.000
Z1	Condenser	attached to the engine	
Z2 (optional)	Filter, radio suppression		Bosch 0 290 801 001

5.4.2 L 2400 DF, DT, DX, EF, ET Engine

BILL OF MATERIALS FOR THE WIRING DIAGRAMB

Sign	Description	Position / Comments	Part-No.
B1, B2	Sender, RPM	attached to the engine	
B3	Sender, throttle position	attached to the engine	
B4	Sender, manifold pressure[2]	mounted behind firewall	
B5	Sender, air temperature	attached to the engine	
B6	Sender, water temperature	attached to the engine	
B7	Sender, fuel pressure	attached to firewall	250.127.220.000
B8	Sender, oil temperature	attached to the engine	
B9	Sender,water temperature	attached to the engine	
B10	Sender, oil pressure	attached to the engine	
B10R	Warning contact oil pressure	attached to the engine	
B12	Sensor manifold pressure	mounted behind firewall (optional)	
B12	Contact coolant level warning	mounted on firewall	

2 On L 2400 DF and EF engines this sensor measures ambient air pressure in a port between intake manifold and air filter

Sign	Description	Position / Comments	Part-No.
F1	Main circuit breaker (50A)	cockpit	ETA 2-5700-K12-55A
FH	Main circuit breaker (40A)	cockpit	ETA 2-5700-K12-50A
G1	Battery 12V-28Ah	airframe / firewall	selection of the designer[3]
G2	Emergency batt. 12V-18Ah	airframe / firewall	selection of the designer[4]
M1	Starter motor	attached to the engine	
M2, M3	Fuel pump, electric	airframe / firewall	250.091.001.000
P1 (optional)	Indicator lamp	cockpit	170.215.120.000
P2	Indicator, oil temperature[5]	cockpit	250.215.010.000 or 170.215.100.000
P3	Indicator, oil pressure	cockpit	250.215.010.000 or 170.215.110.000
P4	Indicator, fuel pressure[6]	cockpit	250.215.030.000
P5	Indicator, engine speed	cockpit	250.215.001.000
P6	Indicator, Water and EGT	cockpit	250.215.010.000
S1	Emergency-switch	cockpit	Supplied with engine
S2	Button, starter	cockpit	selection of the designer
S3	Switch, engine electrics ON/OFF	cockpit	selection of the designer
Y1, Y2, Y3, Y4	injectors	attached to the engine	Supplied with engine
MCU	Relay box	airframe / cockpit	Supplied with engine
ECU	Electronic Control Unit	airframe / cockpit	Supplied with engine

Note The wiring diagram is to German and ISO standards. The symbols are used to eliminate confusion and complication used in other forms of drafting. For example, a square is divided into two sections, the upper section states X4 and the lower 20. This indicates that a cable is connected to the terminal pin 20 of component X4. This is identified from the component list. In the normal operating mode, the engine receives the electrical power from the main battery G1. The circuit energizes thru the relay box (MCU) and the fuses.

To eliminate the possibility of interference by the magnetic field, which can cause inter-action and individual circuit malfunction, the wiring harness uses both plus (+) and negative (-) leads to the components. The leads must be in pairs and twisted. This assists to break down the frequency and reduce the interference of the magnetic field. Two separate paths of the electrical energy to

3 Lead batteries preferred. For other battery types suitability must be investigated.

4 See note 1

5 Instrument P/N 250.215.010.000 is a combination instrument oil temp / oil pressure

6 The fuel pressure indicator is included in the status indicator

supply the fuel-injection system is used. This is because the signals provided and transmitted from the sensors to the ECU are on an independent circuit. The battery acts as a capacitor which dampens the frequency resonance.

Note The chassis negative-wiring system is not permitted with this design. The airframe manufacturer is recommended to refer to the document “Electrical System Design L 2400 EF”. This gives all of the characteristics of the operational behavior of the components included in this system. For example, the function of the switch S3 and the differences of the peculiarities associated with a magneto system.

Pilots and technicians with experience of magneto ignition engines and who are now involved with this type of engine, are advised to become familiar with particular details of this system. With the magneto ignition system, it is instinctive to open the main switch to run the engine. This system is designed so that when the main switch is in the OPEN position, the electrical power is OFF. The main switch is in the cockpit.

The main battery (+) should be switchable over a main relay (main switch), e.g. Kissling 12V/50A order number 26.70.24.

Reversal of the (+) cables on the relay box can lead to a failure of the emergency system.

Warning: **A missing ground connection starter to battery (-) can lead to a cable fire because the voltage in the ground side can flow thru the electromagnetic shielding (EMS) for the engine electrics.**

6 ENGINE MOUNT

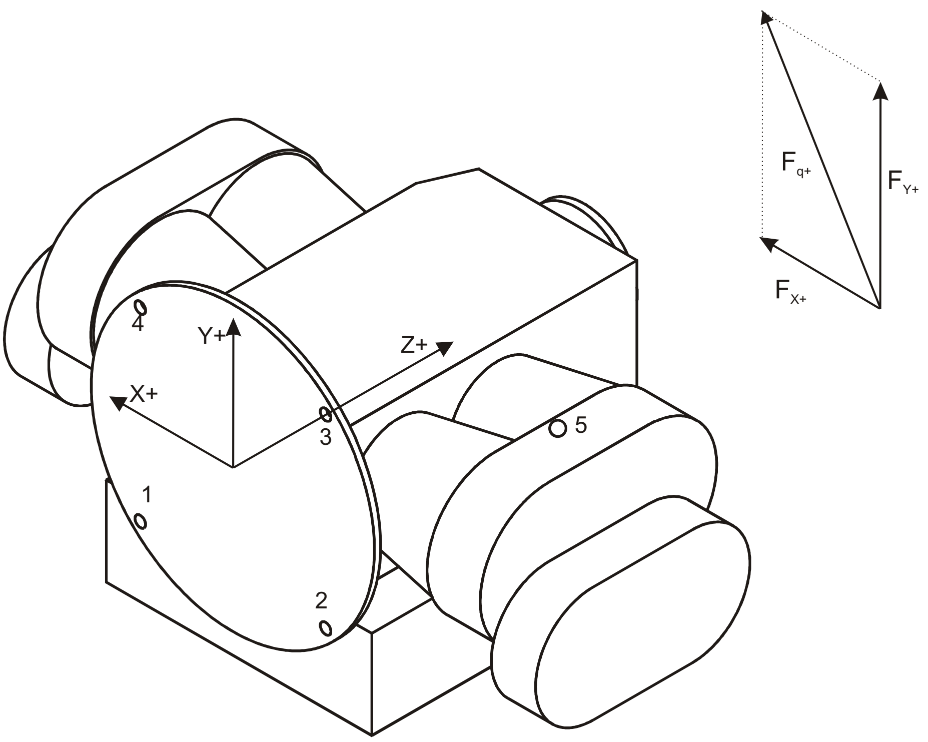

Fig. 6-1 Coordinate System of the Engine for Load Definitions

Possible locations for the mountings are shown on the appropriate drawing for the engine model.

The maximum static loads for each of the rear mounting points (number 1 thru 4) are:

2800N - resulting load (F q1..4) in the direction of the X and Y co-ordinates.

33000N - load combined with pre-tension of the bolt and operational loads in the direction of the Z co-ordinate.

For the front engine mount (number 5):

3700N - resulting load in all directions of the three co-ordinates.

If the front engine mount (number 5) is used, only the two bottom, rear mounts (number 1 and 2) may be used.

The maximum loads shown are static loads which may occur during flight. The maximum vibration load is not defined but must be taken into account in the design factor.

Caution: **Loads imposed on the mountings through the bend moment must not exceed that recommended by the manufacturer. The engine-mount bolts may not be subjected to bend or shear loads.**

LIMBACH-Flugmotoren recommend the use a tubular structure to mount the engine to the airframe. The tubes are set at a low angle of inclination relative to the adjacent structural member. This gives the designer the option of a low bend-moment and rigidity. The shock-mounts are attached to the firewall or between the engine and engine mount.

7 EXHAUST SYSTEM

7.1 General

The design of the exhaust system has a great influence on the performance of the engine. Because of the many different types of aircraft designs, it is not possible to issue detailed guidelines for the design of the exhaust system. The exhaust pipes should be routed away from the engine and use the largest bend radius possible. All of the pipes in the exhaust system should have an expansion joint to minimize the thermal stress. Flexible hoses or tubes are not permitted. Due to in-

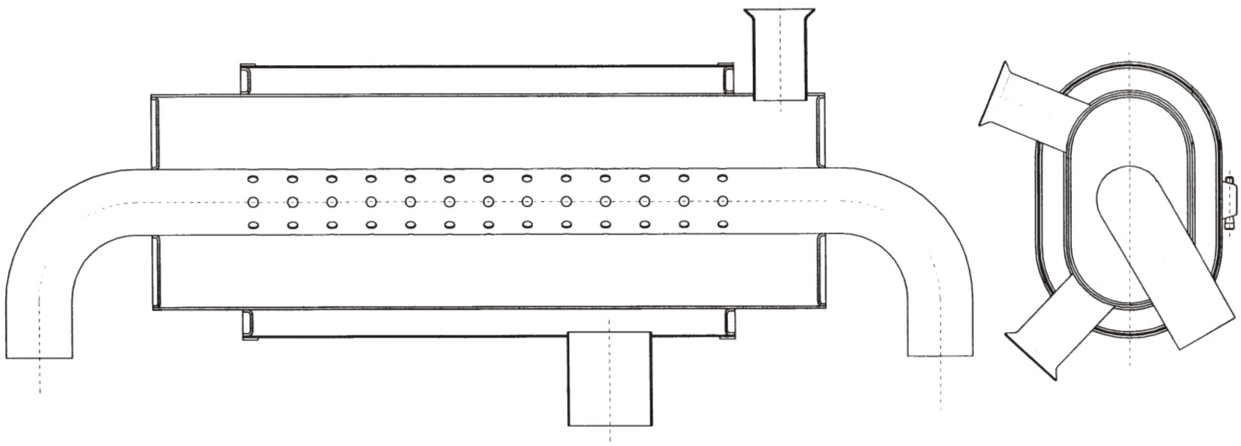

Fig.: 7-1 Sample Exhaust System Layout L 2000 Series

creased requirements to reduce the noise levels, a muffler is recommended. The use of ball/socket/spring connections to the pipe/pot connections makes the installation easier. Movement of the engine must be taken into account.

Dimensioned Drawings are available from LIMBACH Flugmotoren under the following references

Dwg. No.	Description
000.173.001.000	Exhaust System Design Requirements
000.173.100.000	Silencer, Supplementary
000.173.200.000	Exhaust System Layout (Grob G109)

Dwg. No.	Description
000.173.300.000	Exhaust System Layout (Scheibe SF 25C))
000.173.400.000	Exhaust System Layout (Sportavia RF5)

Clamps (e.g. on the oil filter) should be easily accessible for maintenance.

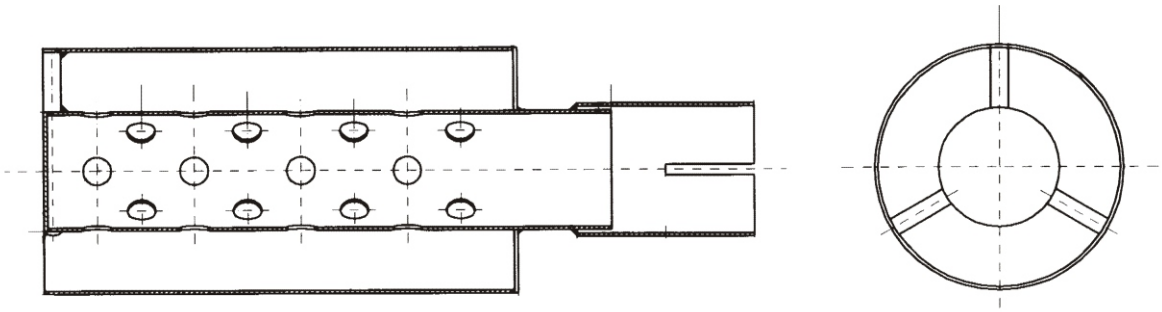

Fig.:7-2 Supplementary Silencer

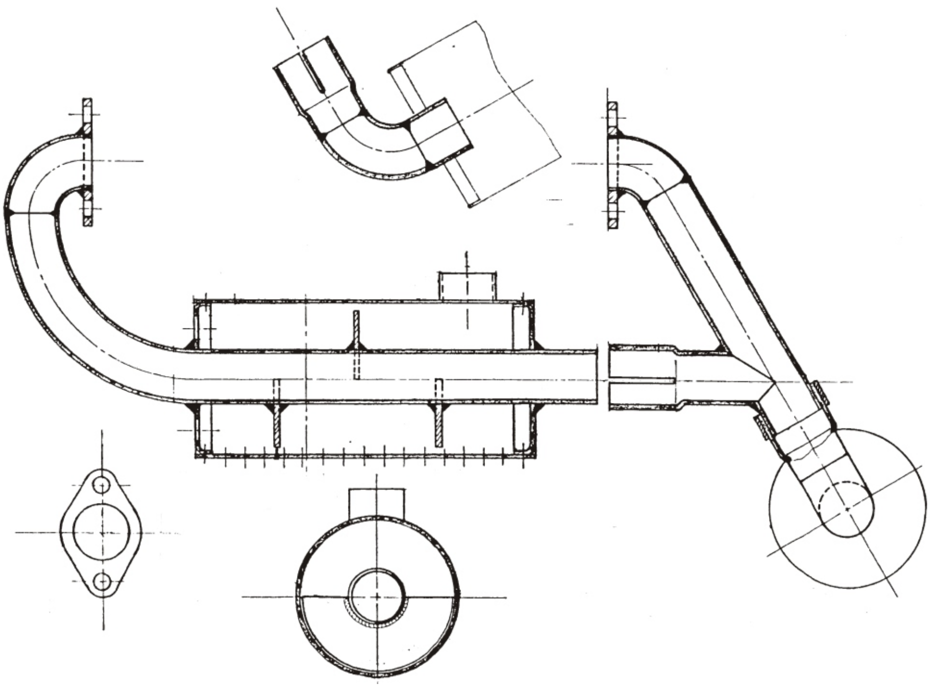

Fig.:7-3 Dual Header Exhaust System (Courtesy RSA France)

Silencers with a single and central exhaust exit tube may be equipped with supplementary silencers for additional noise reduction (Fig. 7-2). For silencers with side exits the additional bending moment imposed on the silencer will be difficult to compensate.

Some installation situations do not accommodate for a single exhaust, or the routing of four independent exhaust pipes gets to difficult. In such cases a dual header exhaust system may be used (Fig.:7-3). Such designs however may create a higher level of back pressure which will reduce the power output and increase the operating temperature of the exhaust valves.

EGT sensors (Type K) should be installed and connected to the engine instruments. The bore should be approximately 50.0 mm behind the flange. Make sure that there is adequate clearance to the pipes carrying inflammable liquid. More detailed information regarding the exhaust system can be obtained from LIMBACH Flugmotoren.

A spoiler at the exhaust outlet will avoid catching pressure air, which would decrease the efficiency of the cooling system.

7.2 L 2400 EF

The exhaust system of the L 2400 EF engine differs from the exhaust system of the air-cooled L 2400 EB1 engine in the connection dimensions, pipe diameters, volume of the pots, position of the outlet and the routing of the pipes.

An EGT sensor (Type K) must be installed at cylinder number 4 and connected to the engine instruments. The bore should be approximately 50.0 mm behind the flange

The inside diameter of the exhaust pipes should be a minimum of 32.0 mm.

Instructions for the amateur aircraft designer can be found in the Oskar Ursinus Vereinigung in Germany.

8 PROPELLERS

The propeller has a considerable influence on the operational characteristics of the engine.

It is not permitted to use any propeller, they must be approved by the aircraft designer/ manufacturer during the aircraft´s certification. Additional information on the approval of propellers is found in Chapter 9, Vibrations.

Most of the propellers have diameters of 1,50 m, 1,55 m or 1,60 m. There are fix pitch or variable pitch propellers available.
The pitch depends on the type of airplane and the engines performance.

At present, the following propeller combinations are recommended:.

8.1 L 2000 Series Engines

Manufacturer, Type and Remarks

Hoffmann HO-V-62/L-160T

Hoffmann HO-V-62/L-160BT, avoid full power over 3000rpm

Hoffmann HO-11*or HO-11A, fixed pitch.

Mühlbauer MT - 1, fixed pitch.

The Operating Manual for the aircraft must contain the limitations for the type of propeller used. The release of a new propeller does imply that existing aircraft may be retrofitted with the new propeller. For further information contact the aircraft- or engine manufacturer.

8.1.1 L 2400 EF Engine

Manufacturer Type Remarks

Mühlbauer MTV 1 A/L 160-06, electrically adjustable propeller, “constant speed“, 2-bladed, to be used at Motor gliders

(Mühlbauer MTV 7 A/L 155-03, electrically adjustable propeller, “constant speed“, 3-bladed, to be tested soon)

Use adapter part number 250.032.510.000 which is delivered with the engine.

9 VIBRATIONS

According to the design, the engine will produce vibrations which may have an influence on the life of the adjacent structure. The maximum acceleration in resonance can be as high as 100 m/sec^2. Therefore resonance conditions must be avoided, or excluded from the usable range of engine speeds with appropriate markings on the RPM-indicator (tachometer).

Pay special attention to the vibration of the rotating system. This consists of the propeller, the spinner assy, the crankshaft and the starter-ring gear. Verify the suitability of a propeller by vibration measurements. The data on the maximum tolerable vibration level is not yet available. Conduct a vibration test for the engine/propeller combinations which are not yet released. For further information, contact the engine manufacturer.

10 COWLING

Design instructions and examples for the ducting of the air.

When designing the air inlets, ducting and the air outlets, the following points must be considered:

- aerodynamic quality of the cowling
- function and efficiency of the cooling system
- supply of intake-air
- good appearance.

10.1 L 2000 and Series

The valid edition of the Technical Bulletin 44 gives useful instructions for the design (TB 44.1).

The carburetor should get it´s air out of a kind of box, in which the air get´s calm.

Make sure that the outlet is not blocked, e. g. by the muffler.

10.2 L 2400 EF Engine

10.2.0.1 Air Inlet

Air inlets are required for:

- cooling air for the cylinders. These are connected to the cooling-air ducts mounted on the engine. There is one each on the left and right of the spinner (refer to NASA report)
- cooling air for the oil cooler, NACA inlet, on the right side of the cowling
- cooling-air inlet, a slit in the shape of a shark's mouth for the radiator, at the bottom of the cowling
- inlet for the engine intake-air, NACA inlet. An accumulator, with an air-intake arch and an air filter, is mounted on the engine. The air filter sits in a container.

10.2.0.2 Air Ducting

The container for the air filter is attached to either the engine mount or the cowling and should be sealed at the cowling as good as possible. Fresh air, at a slightly higher atmospheric pressure, flows to the air-filter container through the NACA inlet on the left side. The pipe to the air-pressure sensor (in the cockpit, plug B4) is connected to the composite arched-pipe installed between the throttle and the air filter.

The air-intake arch must not be modified because the geometry has an appreciable influence on the performance of the engine.

The oil cooler can be housed in a container attached to the cowling, retained by quick-release fasteners.

10.2.0.3 Air Outlet

In many cases the air outlet also serves to duct the exhaust pipes. The effective outlet section for the cooling air should be 6 dm2 configuration. Under no circumstances must there be evidence of ram-air pressure when the aircraft is at a greater angle of incidence, e.g. in a climb.

The valid edition of the Technical Bulletin 44 gives useful instructions for the design of the cooling-air outlet.

Make sure that the outlet is not blocked, e. g. by the muffler.

10.3 Engine Breather

LIMBACH engines are wet sump forced lubricated. Therefore it is necessary to assure a proper crankcase breathing. Never give pressure air to the crankcase breather line. Be sure that icing is impossible. For more information see Operating and Maintenance Manual of the engine.

Warning: A blocked breather line will cause oil leakages to the engine!

11 Literature

Limbach Flugmotoren	Operating Manual L 2400 EF and series P/N 250.253.001.000
Limbach Flugmotoren	TB 44 Too High Engine Temperatures
Bingelis, Tony	Firewall Forward, Engine Installation Methods 1983 (Available through EAA, Experimental Aircraft Association)
Miley, S. J.; Cross, E. J.	An Experimental Investigation of the Aerodynamics and Cooling of a Horizontally-Opposed Air-Cooled Aircraft Engine Installation; NASA Contractor Report 3405