



**Installation manual**  
**SPIRIT engines**

Document  
**E-DMA.E10.1**

Edition  
**A**

Revision  
**1**



**INSTALLATION Manual for**  
**SPIRIT engines**

	<b>Installation Manual for SPIRIT engines</b>	Document <b>E-DMA.E10.1</b>	
		Edition <b>A</b>	Revision <b>1</b>



**In-flight use of the engine certifies that the user has read and understood the contents of the installation manual and the operating manual. Failure to follow the instructions contained herein can cause serious injury and even death. Refer to the aircraft instruction manual for additional information.**

***All information, illustrations, instructions and technical data contained in this manual has been upgraded before printing. MWfly reserves the right to modify, correct or upgrade general data at any time without any obligation or prior consent from third parties. Publication of any part of this document without written consent of MWfly is strictly prohibited.***

***This Manual forms part of the engine and must be kept safe. It must accompany the engine in case of sale to a new owner. The original document is written in Italian and this language will be used to settle any dispute of a legal or technical nature.***

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## 01-00-00 INTRODUCTION

The **SPIRIT** series of engines are designed and manufactured using the most modern motor technology with the purpose of achieving good performance combined with a high level of passive safety. If the engine is used correctly it will return years of pleasure and reliable service.

Please read this manual carefully before using the engine and apply all safety standards contained in it, in addition to those that your experience and common sense suggest.

MWfly will be happy to provide additional information and all the technical support you will need.



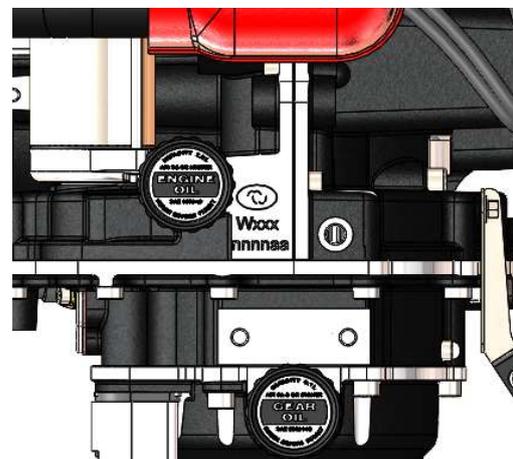
Unless otherwise specified, the engine is delivered without engine oil, gear oil and coolant. Before starting the engine, you must fill of systems.



The engine must be started only after the installation is completed and with propeller mounted: not doing so will cause serious damage to the starter system.

## 01-01-00 Identification Data

The engine serial number is stamped on the top of the engine, near the gearbox. It consists of the model identification code (72-02-C) followed by a six-digit number, of which the first four indicate the serial number and the last two indicate the year of manufacture.



01-01-P

Removing or modifying the serial number will revoke any warranty and obligation by MWfly toward current owner.

Provide the serial number on any request for an engine part or technical information.

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## 01-02-00 Documentation

### 01-02-01 Notes for Consultation

This manual describes how to install the **SPIRIT** series of engines. Prior to commencing work on engine installation, it is crucial to read and understand the contents of this document. This manual contains all basic information for correct installation and safe operation.

If any steps prove difficult to understand or there is any doubt, please contact an authorized MWfly Service Centre.

For additional or more detailed information consult the Operational Manual, the Maintenance Manual and the Additional Maintenance Manual.

It is fundamental to integrate the information of this manual with the safety precautions of the aircraft manufacturer and with safety conditions from your personal experience.



**This engine has not received any certification for aeronautical use.**

**It must be used exclusively on experimental aircraft where an engine failure will not compromise flight safety. Its use in certified aircraft is strictly prohibited.**



Engine installation must be done taking into consideration the governing aviation law, rules and regulations in force in the country where the engine will be used.

This manual was originally printed in Italian. This will be the only language used for any reference or dispute.

The manual is divided into chapters; each chapter is divided into sections; each section is divided into paragraphs; within each paragraph there may be a further subdivision into topics. The title of each chapter, section, paragraph or topic is highlighted as follows.

## CHAPTER

### Section

#### Paragraph

#### Topic

The numbering system of the contents of the manual consists of a numerical code using the following criterion.

The content of each document is numbered and divided as follows.

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## CC-SS-PP

where

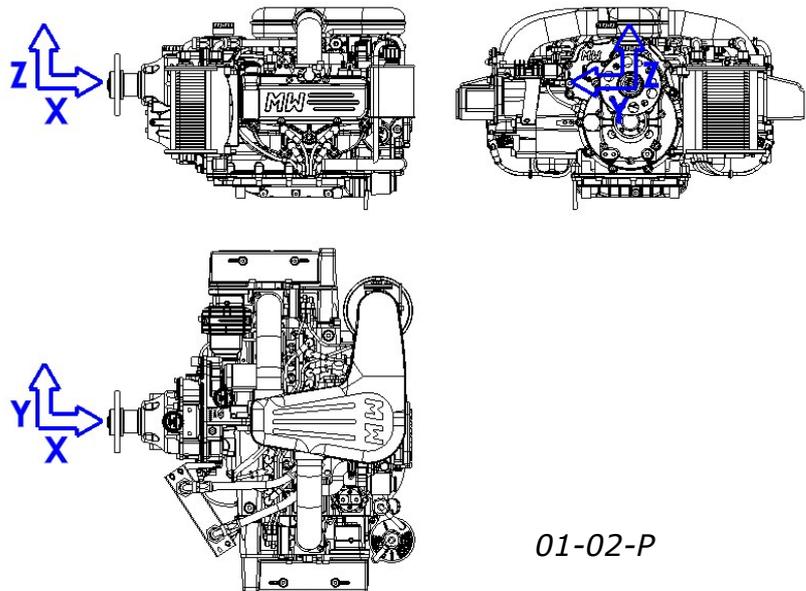
- CC** indicates the chapter of the document
- SS** indicates the section of the document
- PP** indicates the paragraph of the document

The subdivision into CC (chapters) will follow the ATA-100 scheme. The subdivision of the first digit of each section will also respect the ATA 100 scheme; the second digit of each section is assigned by MWfly, to correctly subdivide the topic.

Within each section, the numbering in paragraphs will follow a progressive numbering, starting from number 01.

The identification of the figures and tables shows the chapter number and a progressive number, followed by the letter P for the figures and the letter C for the tables (e.g. 21-03-P).

The triad of reference axes used in the manual is a right triad that originates on the helix axis, at the intersection with the helix support plane: the x axis originates on the support plane of the flange itself and is positive in the direction of the engine, the y axis is positioned with origin on the centre line of the engine and is positive in the direction of the cylinder bank # 1, the z axis originates on the propeller shaft and is positive upwards, on the intake manifold side.



Symbols used in this manual have the following meaning.



**WARNING: Not following this instruction can cause severe personal injury or loss of life.**



**CAUTION: Not following this instruction could cause severe damage to the engine or other components and cause the engine to stop.**



**NOTE: Refers to supplementary information to completely or fully understand the instruction.**

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- 1., 2., ... This numbering is used to list tools and consumables needed to run an installation or maintenance; it is also used to bring in parts lists or engine parts shown in the illustrations.
- a., b., ...** This lettering is used to indicate a list of actions or subjects with relation to inclusion: all of the actions or options listed must be verified.
- This symbol is used to indicate a list of actions or subjects with relation to exclusion: only one of the actions or options listed with this symbol must be verified.
- This symbol is used to list the general characteristics of the engine, component specifications or options for installation or maintenance.
- (...) A text enclosed in brackets clarifies an aspect, or constitutes an example or a reference to a chapter of the same or another document (e.g. DMB.E10.2.3).

### 01-02-02 Unit of Measure

All the units of measurement reported in this and other MWfly manuals are expressed in technical units (ST), judged to be more usable and understandable than the units of the International System (SI). Table 01-01-C shows the conversion factors between the technical units used in compiling the manuals, the equivalent units of the International System and the equivalent units of the Imperial System. To obtain from the quantities expressed in technical units the corresponding value in For S.I. or Imperial simply multiply by the coefficient shown in the tables. As an example, we report some conversions.

$$100CV = 100 * 0,735kW = 73,5 \text{ kW}$$

$$100CV = 100 * 0,986Hp = 98,6 \text{ Hp}$$

$$82 \text{ Kgf} = 82 * 9,81 \text{ N} = 804,42 \text{ N}$$

$$82 \text{ Kgf} = 82 * 2,205 \text{ lb} = 180,8 \text{ lb}$$

If in doubt about the meaning of the measurements, their value or interpretation, contact an authorized MWfly service centre. If measurements made on the engine or relating to it refer, these must be expressed in units consistent with the Technical System used in the manuals, which is the only one adopted by MWfly.

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<b>CONVERSION FACTORS BETWEEN MEASUREMENT SYSTEMS</b>			
<b>Type of measurement</b>	<i>ST Unit</i>	<i>S.I. Unit</i>	<i>Anglo-saxon unit</i>
<i>Length</i>	cm mm	m = 100cm = 1000mm	ft = 30,48cm = 304,8mm in = 2,54cm = 25,4mm
<i>Surface</i>	cm <sup>2</sup> mm <sup>2</sup>	m <sup>2</sup> = 10 <sup>4</sup> cm <sup>2</sup> = 10 <sup>6</sup> mm <sup>2</sup>	sq ft = 77,42cm <sup>2</sup> = 7741,9mm <sup>2</sup> sq in = 6,45cm <sup>2</sup> = 645,16mm <sup>2</sup>
<i>Volume</i>	cm <sup>3</sup> mm <sup>3</sup>	m <sup>3</sup> = 10 <sup>6</sup> cm <sup>3</sup> = 10 <sup>9</sup> mm <sup>3</sup>	cu in = 16,3871cm <sup>3</sup> cu ft = 28316cm <sup>3</sup>
<i>Capacity</i>	L	m <sup>3</sup> = 10 <sup>3</sup> L	gal (UK) = 4,5461L gal (US) = 3,7854L
<i>Mass</i>	Kg g	Kg = 10 <sup>3</sup> g	lb = 0,453Kg = 453g
<i>Weight</i>	Kgf gf	N = 9,81Kg = 9814g	lb f = 2,205Kgf = 2205gf
<i>Density</i>	g/cm <sup>3</sup>	Kg/m <sup>3</sup> = 10 <sup>-3</sup> g/cm <sup>3</sup>	lb/ft <sup>3</sup> = 62.43g/cm <sup>3</sup>
<i>Flow Rate</i>	m <sup>3</sup> /h m <sup>3</sup> /min m <sup>3</sup> /s	m <sup>3</sup> /s = 1/3600*m <sup>3</sup> /h m <sup>3</sup> /s = 1/60*m <sup>3</sup> /min	cu ft/s = 0,0284 m <sup>3</sup> /s
<i>Force</i>	N	N	lbf = 4,448N
<i>Pressure</i>	bar mbar	Pa = 10 <sup>-5</sup> bar = 10 <sup>-2</sup> mbar	psi = 0,0689bar = 68,9mbar in Hg = 0,0338bar = 33,8mbar
<i>Torque</i>	Kgm	Nm = 9,81Kgm	ft lb = 0,138Kgm
<i>Power</i>	CV	kW = 0,735CV	Hp = 0,986CV
<i>Fuel Consumption</i>	g/CVh	g/kWh = 1,359g/CVh	lb/Hph = 447,59g/CVh
<i>Time</i>	s min h	s = 1/60min = 1/3600h	s
<i>Velocity</i>	m/s Km/h	m/s = 1/3,6Km/h	kn = 1,852Km/h = 0,514m/s
<i>Temperature</i>	°C	K = °C-273,15	°F = (1,8*[°C])+32

01-01-C

Table 01-02-C shows the conversion between the section of the electrical cables, expressed in square millimetres, and the corresponding AWG measurement, most commonly used by installers.

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ELECTRICAL CABLES SECTION CONVERSION									
<i>mm<sup>2</sup></i>	21,200	13,300	8,350	5,270	3,310	2,080	1,310	0,820	0,519
<i>AWG</i>	4	6	8	10	12	14	16	18	20

01-02-C

### 01-02-03 Technical Documentation Available

The technical documentation and directives are to be considered a necessary tool for personal training, but they cannot in any way replace adequate specific instruction, both theoretical and operational

The information provided in the following manuals contains procedures and checks that can be carried out by qualified professionals operating in the sector.

- DMA.E10 - Installation manual: contains the information necessary for the proper installation of the engine.
- DMB.E10 - Operating manual: contains the information necessary for the proper use of the engine.
- DMC.E10 - Ordinary maintenance manual: contains the information necessary for the compliant execution of scheduled maintenance.
- DMD.E10 - Extraordinary maintenance manual: contains the information necessary for the execution compliant with unscheduled maintenance, i.e. determined by failures.
- DME.E10 - illustrated spare parts catalogue: contains the list of spare parts and accessories expected.
- DSL.E10 - service letter: contains information aimed at improving the product or use of the same.
- DSB.E10 - Service bulletin: reports the substitutions, checks or warnings to be applied within the indicated deadline.



The variety of installations can make the information contained in the aforementioned manuals inapplicable, inadequate or insufficient.

The illustrations in this manual do not represent in detail the details of the engine, but provide an indication of their function and structure: for these reasons it is not possible to deduce dimensional information or verify details from the published illustrations.

All further necessary documentation is however available at the MWfly authorized service centres.

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## 01-03-00 Safety

Just reading this manual will not eliminate the hazards connected to the installation and use of the engine. However, understanding and applying the information herein is essential for proper and safe use of the engine.

The onus to install this engine is at the sole discretion and responsibility of the Original Manufacturer, Home Builder or Aircraft Owner. MWfly cannot assume responsibility for a successful installation in a specific airframe due to the variety of designs existing in the market. For this reasons MWfly declines responsibility regarding damage to engine parts, accessories or aircraft structure during the installation and use of this engine. The owner accepts the responsibility and the risk in using this engine.

The information, components, system descriptions, pictures, tables and technical data contained in the present manual are correct at the time of publication. MWfly, however, maintains a policy of continuous improvement of its products without imposing upon itself any obligation to install them on its products previously manufactured: should such an eventuality arise, MWfly, through its distribution and assistance network, as well as through the website [www.mwfly.it](http://www.mwfly.it), will disclose the mandatory nature of any update.

MWfly reserves the right to make changes at any time, without notice and without incurring any obligation. No part of this publication may be reproduced without written permission.

To carry out installation or maintenance work, use the consumables, accessories and tools specifically provided and detailed at the beginning of each paragraph.

For your safety, here are some important tips, suggested by common sense and by the usual norms of prudence, without however being able include all of the situations or behaviours that constitute opportunities for potential risk.



**Installation or any kind of adaptation not performed in accordance with the technical requirements of the manuals or by staff not authorized to operate on the product itself are a source of grave danger and releases MWfly from any obligation and responsibility to the user.**



**Never operate the engine in an enclosed space. The exhaust fumes contain carbon monoxide, a very poisonous gas, which if inhaled in excessive quantities quickly leads to loss of consciousness and death.**



**Carry out an adequate inspection before starting the engine for the first time: this helps to prevent accidents or damage. In case of doubt about installation first contact an authorized service centre.**

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**MWfly SPIRIT engine is not suitable for aerobatics.**



**The technical documentation and guidelines are considered a necessary tool for staff training, but cannot in any way substitute for adequate specific instruction, either theoretical or operational.**



For the engine installation, strictly follow all laws and national and local regulations.



Only authorized and technicians trained on the product are qualified to work on the engine.



Before starting the engine for the first time, make sure you have filled up the engine with engine oil, gear oil and coolant.



This engine has received no airworthiness certification, nor is it subject to any aeronautical standards. Its use is intended for experimental aircraft or certificates, on which a possible engine failure does not affect the flight safety. You assume all risks arising from the use of the engine and recognize and are aware of the foregoing.



The engine is intended for daytime use only.



Do not start the engine without the propeller: this may cause serious damage to the engine.



Do not use, under any circumstances, propellers with moment of inertia greater than specified: this will release MWfly from any liability and all warranty obligations.



On the ground, during a ground runup or engine stand run, avoid running the engine over 3200rpm for more than 1 minute, since the cooling flow may be inadequate and cause an engine component failure.



Improper installation and the use of unsuitable components for the fuel supply system, the cooling and the lubrication system releases MWfly from all liability.

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The engine is delivered with protection caps on the intake manifolds, the exhaust manifolds, the manifolds of the cooling system and the fuel circuit IN and OUT: these caps must be removed during installation just before making the connection, to avoid foreign bodies entering inside the engine.



This installation manual is part of the technical documentation and must be integrated with the operating manual, the maintenance manual, the heavy maintenance manual and the illustrated spare parts catalogue. When reading this manual, pay attention to references to parts of other manuals.

When there are differences between what is specified in this manual and local regulations, you must proceed under the more stringent rule.

#### 01-04-04 Modifications and Accessories



**Any change or removing parts of the engine is potentially dangerous: in particular the replacement of engine parts with non-original parts can seriously affect the technical characteristics and reliability of the engine.**



Any type of modification, replacement or removal of the engine parts that are not approved in advance in writing by MWfly, causes the immediate revocation of the guarantee and releases MWfly from any further obligation or liability to you.

MWfly accessories have been specifically designed and tested for use with this engine: since MWfly cannot proceed to test all aftermarket accessories, you are responsible for the proper selection, installation and use of the above. For the correct accessory choice, pay attention to the following requirements.



**Carefully examine and verify that the accessory does not interfere with any moving part of the engine, especially with the throttle and the propeller.**



**For no reason intercept or modify the electrical wiring of the engine, or change the mapping tables of the ECU (engine Control Unit).**



Avoid installing accessories that hamper the flow of the engine coolant.

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In the installation of electrical or electronic equipment, check that the total requirement does not exceed the electrical output from the generator.



Any electrical load must be connected to the battery terminals with the interposition of a suitable fuse, better still, a restorable type (breaker).



The use of non-original accessories and those not specifically approved in writing by MWfly, causes the immediate suspension of the guarantee and releases MWfly from any further obligation to you.



Mounting accessories in points not indicated that involve the removal or loosening of clamping screws, causes the immediate suspension of the guarantee and releases MWfly from any further obligation or liability to you.



For the installation and maintenance activity use the consumables, detailed accessories and tools listed at the beginning of each paragraph.

In particular, the user assumes all risks arising from the use of the following accessories, if not original:

- exhaust system
- anti-vibration mounts
- water radiator
- oil cooler
- fuel pump
- fuel filter
- auxiliary generator

## **01-05-00 Tools and Consumables Required**

Below is the list of the minimum set of tools and consumables required to complete the installation. Before starting work make sure that you have everything you need.

### *01-05-01 Tools Needed*

- T-handle allen key 5 mm
- T-handle allen key 6 mm
- T-handle allen key 8 mm
- Open end wrench 13 mm
- Open end wrench 17 mm
- Open end wrench 19 mm

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- Torque wrench 0-50 Nm
- PHILLIPS screwdriver 4 mm
- Slot head screwdriver 4 mm
- Half-round nose plies

### 01-05-02 *Materials Needed to Complete the Installation*

- 4 screws - M10x1.5 to fix the engine with self-locking nut and locknut
- 1.2mm accelerator cable with relative terminals
- Hose 8mm internal diameter for fuel system 3.5 bar and its clamps
- 2 banjo and 2 banjo bolts M12x1.5 for fuel system
- Ground cable AWG 5 (17 mm<sup>2</sup>)
- Power cable for starter AWG 5 (17 mm<sup>2</sup>)
- Ethylene glycol ~4,6 L
- Engine oil ~3,55 L
- Gear box oil ~0,65 L
- Fuel valve
- Key switch
- 2 panel switches
- Push button

If you do not use all the original components provided in the catalogue, in addition to the above-mentioned material you must add the following:

- Pipes, fittings and clamps for liquid cooling system internal diameter 32 mm
- Coolant radiator
- Pipes, fittings and clamps for oil cooling system inside diameter 7 mm
- Oil cooling system radiator
- T-fittings and small parts for parallel mounting of fuel pumps
- Exhaust system complete with manifolds muffler, springs and clamps

### 01-06-00 **Storage**

When stored in the delivery condition, the engine is protected against corrosion for a maximum period of 6 months from date of shipment.

The corrosion warranty is valid for maximum storage period 6 months and under the following conditions.

- a.** The engine should be stored in its original packaging and unopened.
- b.** All covers to protect the engine must not be removed.
- c.** The storage and transport temperature must never exceed 45 °C, nor go down below -10 ° C.



In case of a prolonged period of storage before installation over 6 months, it is necessary to carry out all the required checks and operations.

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### 01-06-01 Protection Covers

All openings are protected against ingress of foreign bodies: it is recommended to not remove the caps until installation is completed. Keep the covers for future reuse.

#### List of Protection Covers

- Cylinder exhaust opening
- Inlet and outlet fuel line of the fuel distributor
- Inlet and outlet pipe cooling system to the water pump cover
- Inlet and outlet lubrication line (only in the case that the OC-m is not pre-assembled)



The protective covers must be used only for transport and for installation and must be removed before engine use.

### 01-07-00 Engine Handling

The engine is delivered in a wooden box, which is screwed through four threaded holes on the oil sump: any exhaust system is delivered tied to the base of the case, disconnected from the engine. The radiator can be delivered separately from the engine.



**The screws used to attach the motor to the crate are to be used solely for transport and may not be reused.**



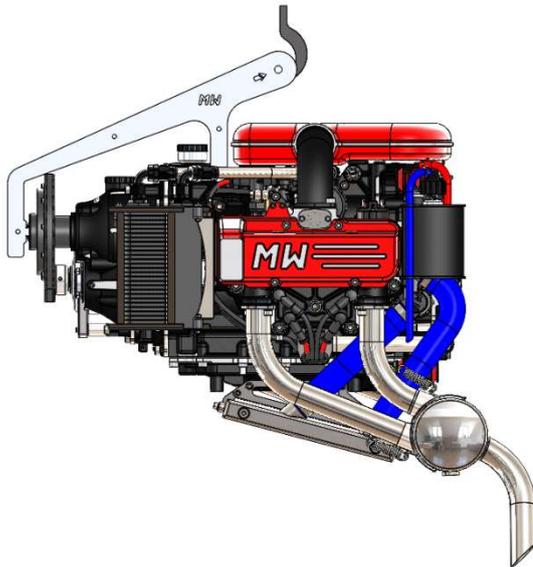
Secure the crate to avoid any damage or overturning during transport.



The attachment points on the engine where it attaches to the crate can be used to attach accessories, such as the radiator, to the engine, but cannot be used to fix the engine to the aircraft.



Pay attention while moving the engine, use caution to prevent injuries and material damage.

*01-03-P*

To lift the engine, use the hook (code X299) provided. The hook is wedged in the propeller flange and fixed to a through hole at the top/front engine casing with an M8x55 mm bolt. Lift the engine from the shaft indicated by the arrows. The position of the shaft is in line with the centre of gravity, the propeller axis will be almost horizontal.

In case the hook is not available, it is possible to lift the engine using a rope around the propeller shaft and the top rear mounting point.



The rope should be long enough to pass over the intake manifolds to avoid damage.



Avoid passing the lifting ropes below the heads, to avoid damaging spark plugs and spark plug cables.

### **01-08-00 MWfly Authorized Service Centres**

For more information on maintenance or on the spare parts, please contact the nearest MWfly service centre (check on [www.mwfly.it](http://www.mwfly.it)).

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## 10-00-00 ENGINE INSTALLATION

The following notes should be considered precautionary measures to be followed for the installation in order to avoid injury or damage to the engine.

A good installation produces, as a consequence, safer use of the engine by increasing the operational life. It is therefore necessary to proceed carefully, as much as possible, by following the rules and instructions specified in this manual and integrating with the information contained in other documentation

In particular, it is necessary to verify that the installation allows the engine to reach, and not to exceed, the temperature and pressure operating limits: for this purpose, it is recommended to use a data acquisition system that can be connected to the ECU's CAN line, to record all the engine parameters that can be combined with the flight parameters.



Start up the engine only when the installation is completed and with the propeller mounted. Not following this procedure can cause serious damage to the engine.

## 10-01-00 Mounting Position

The architecture of the **SPIRIT** engines allows dynamic balancing of the engine shaft to be almost perfect. This peculiarity allows balance of 100% of the inertia forces of the first and second order, besides the inertia of the first order moments. The vibrations of the engine will then be caused by the imbalance of only second order moments that are of minimum entity, with a frequency that is the double of frequency of explosion in the combustion chamber and with very low amplitude.

Another source of vibrations, predominant at low speeds, is related to the pressure forces on the pistons, in other terms the forces produced by the combustion. These forces produce low frequency vibrations and medium amplitude especially at idle or slightly higher engine speed: the antivibration suspension, designed for boxer engines, must be able to absorb the vibrations induced by the combustion, because the one produced by dynamic loads are of very modest entity, and of higher frequency and therefore less noticeable and less hazardous to the structure of the aircraft.

For a good vibration isolation, it is desirable to have the vibration-damping elements with the yielding axis horizontal and transversal to the propeller shaft, by this way the allowed movement does not produce movements of the propeller outside of the plane of rotation: by doing that no additional stress will be produced on the propeller and on the propeller shaft, with an advantage for comfort and safety of the flight. For this reason, it is appropriate to use wall mounting, which provides a more advantageous arrangement of vibration-damping elements as opposed to bed mounting.

Finally, it is appropriate that the anti-vibration elements are positioned between the engine and the engine frame, with the dual aim of isolating the aircraft from vibrations and reducing the unsprung weight: keep in mind these benefits if you want to use the front support F, for which there is no housing for antivibration.

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The engine must be fitted on the fuselage with the propeller axis horizontal or slightly inclined, only a small deviation is permitted. In all cases the engine sump must remain at the bottom.

The **SPIRIT** engine can be used on both a traction application and a pushing application.



**Make sure that no part of the aircraft touches or can accidentally touch the engine hot parts (pay particular attention to the area around the exhaust system).**

Thanks to the absence of carburetors and the adoption of the electric fuel pump with safety valve, there needs to be no special precautions taken regarding the engine position with respect to the fuel tanks in order to avoid hydraulic lock of the cylinders due to the fuel drainage in the engine. It is recommended however, also to simplify the maintenance operations and increase the level of safety of the installation, to adopt a valve on the fuel supply circuit, especially in applications of high-wing aircraft.

To counteract the lateral thrust of the propeller (drift), which tends to make the aircraft deviate in the opposite direction to that of rotation, it is advisable to rotate the propeller's traction axis in the direction of rotation of the propeller: for example, in the case of motors with left-hand spinning propeller, the motor itself must be rotated to the left. Usually about 2 degrees of deviation is sufficient to have an adequate straightening effect. The optimum angle must be found experimentally, whereas an insufficient rotation will produce an excessive intervention of left pedal during take-off, while excessive rotation will limit the speed performance of the aircraft and the controllability in transition between minimum and maximum power. The drift effect compensation must also be balanced by the use of a compensating flap on the rudder (trim). However, there are no operating limits for the angle of lateral deviation of the propeller shaft with respect to the longitudinal axis of the aircraft.

Ideal deviation on a vertical axis is such that the propeller axis will be above the CoG by 15/20 cm. Normally this angle is close to 0 or can be out by 1 to 2 degrees in a nose down configuration. Even in this case, the optimum angle can be found by experiment, verifying that subsequent to an increase in engine power the aircraft responds with a change of trim to pitch. To attain good lubrication the engine angles must never exceed data reported in table 10-7-C.

The layout of the two cylinder heads with reference to the horizontal line is 0 deg. In case of the specific need where one cylinder head is positioned lower than the other do not exceed the max angle indicated to avoid excessive oil build up in the lower cylinder.

### 10-02-00 Fixing Points

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**10-02-01 Position of the Engine Fixing Points**

Built into the engine, there are nine mounting points. In a standard wall installation, the mounting points are on the rear side labelled R. For standard bed installation use the four lower attachment points labelled L, whose supports are supplied as optional (BM-m); a combination of L and R attachment points can also be used to install the engine into the airframe.

The rear and lower fixing points are machined to house the rubber dumpers: all engines are delivered with 8 dampers and relative aluminum spacers.

On the front top part of the engine, labelled with an F there is an additional attachment point. The F attachment point should be used in combination with at least two R or two L attachment points. Using the F attachment point it is mandatory to use a damping element between the engine and the engine frame.

The type of attachment of the engine is mainly determined by the design of the aircraft.

The coordinates of the attachment points are indicated in the following tables, for both Direct and PSRU versions.

<b>Direct Version</b>				
<b>Coordinates wall attachment point [mm]</b>	<i>Point R1</i>	<i>Point R2</i>	<i>Point R3</i>	<i>Point R4</i>
X	541	541	541	541
Y	100	137,5	-100	-137,5
Z	-135	165	-135	165

10-01-C

<b>Direct Version</b>				
<b>Coordinates bed attachment point [mm]</b>	<i>Point L1</i>	<i>Point L2</i>	<i>Point L3</i>	<i>Point L4</i>
X	149,9	463,3	149,9	463,3
Y	98	98	-98	-98
Z	-157,3	-157,3	-157,3	-157,3

10-02-C

**Direct Version**

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Coordinates front attachment point [mm]	<i>Point F</i>
X	203,6
Y	± 20
Z	174

10-03-C

<b>PSRU Version</b>				
Coordinates wall attachment point [mm]	<i>Point R1</i>	<i>Point R2</i>	<i>Point R3</i>	<i>Point R4</i>
X	617	617	617	617
Y	100	137,5	-100	-137,5
Z	-218,2	81,8	-218,2	81,8

10-04-C

<b>PSRU Version</b>				
Coordinates bed attachment point [mm]	<i>Point L1</i>	<i>Point L2</i>	<i>Point L3</i>	<i>Point L4</i>
X	225,9	539,3	225,9	539,3
Y	98	98	-98	-98
Z	-240,5	-240,5	-240,5	-240,5

10-05-C

<b>PSRU Version</b>	
Coordinates front attachment point [mm]	<i>Point F</i>
X	279,6
Y	± 20
Z	90,8

10-06-C



To install the engine on the air frame use bolt class 8.8 or superior grade. Do not use stainless steel or titanium bolts.



The tightening torque is essentially determined by the aircraft design. It is suggested to use a tightening torque of 35÷45 Nm.

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The following drawing indicates the dimensions of engine attaching point holes for both versions with or without gear box.

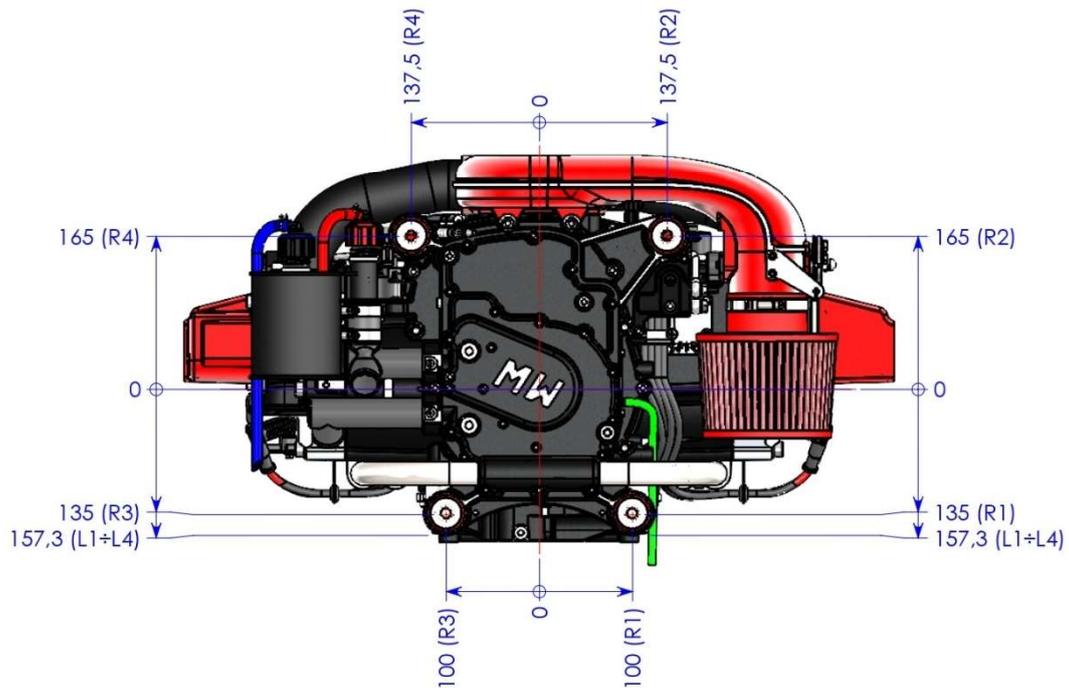
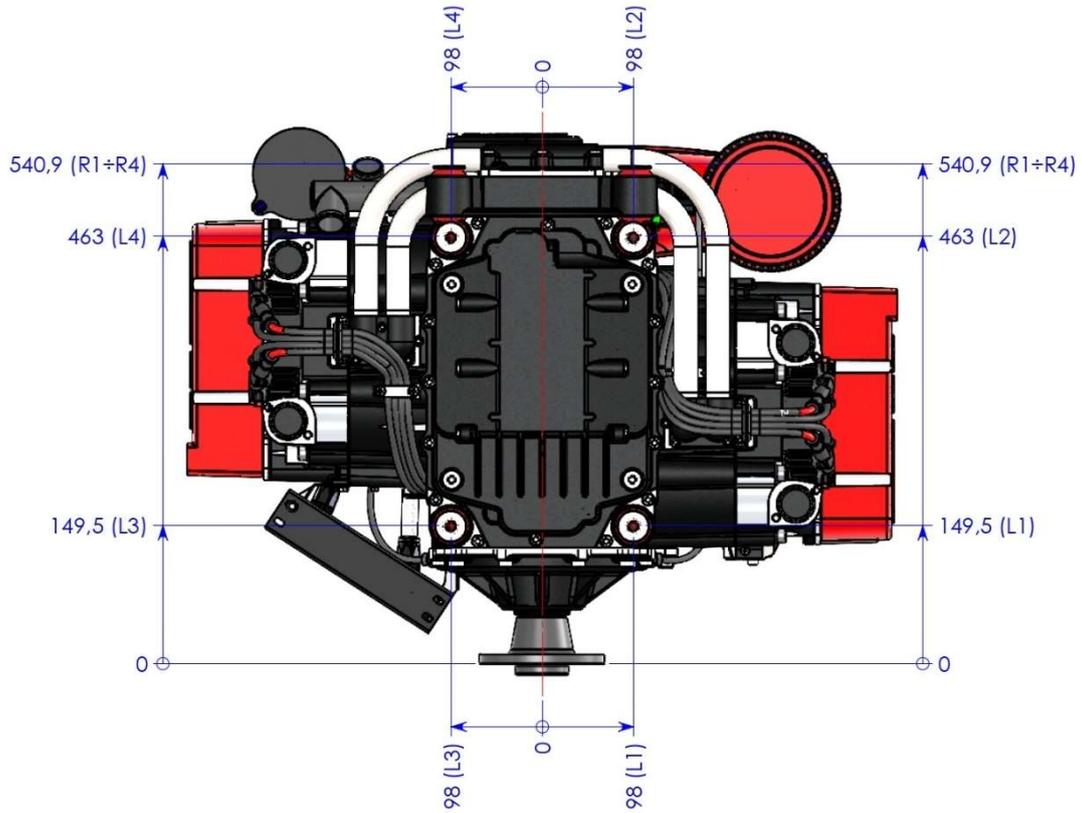


If the R fixing points are used, it will not be possible to use the rear L points (L2 and L4); vice versa, using the L fixing points, it will not be possible to use the lower R points (R1 and R3).



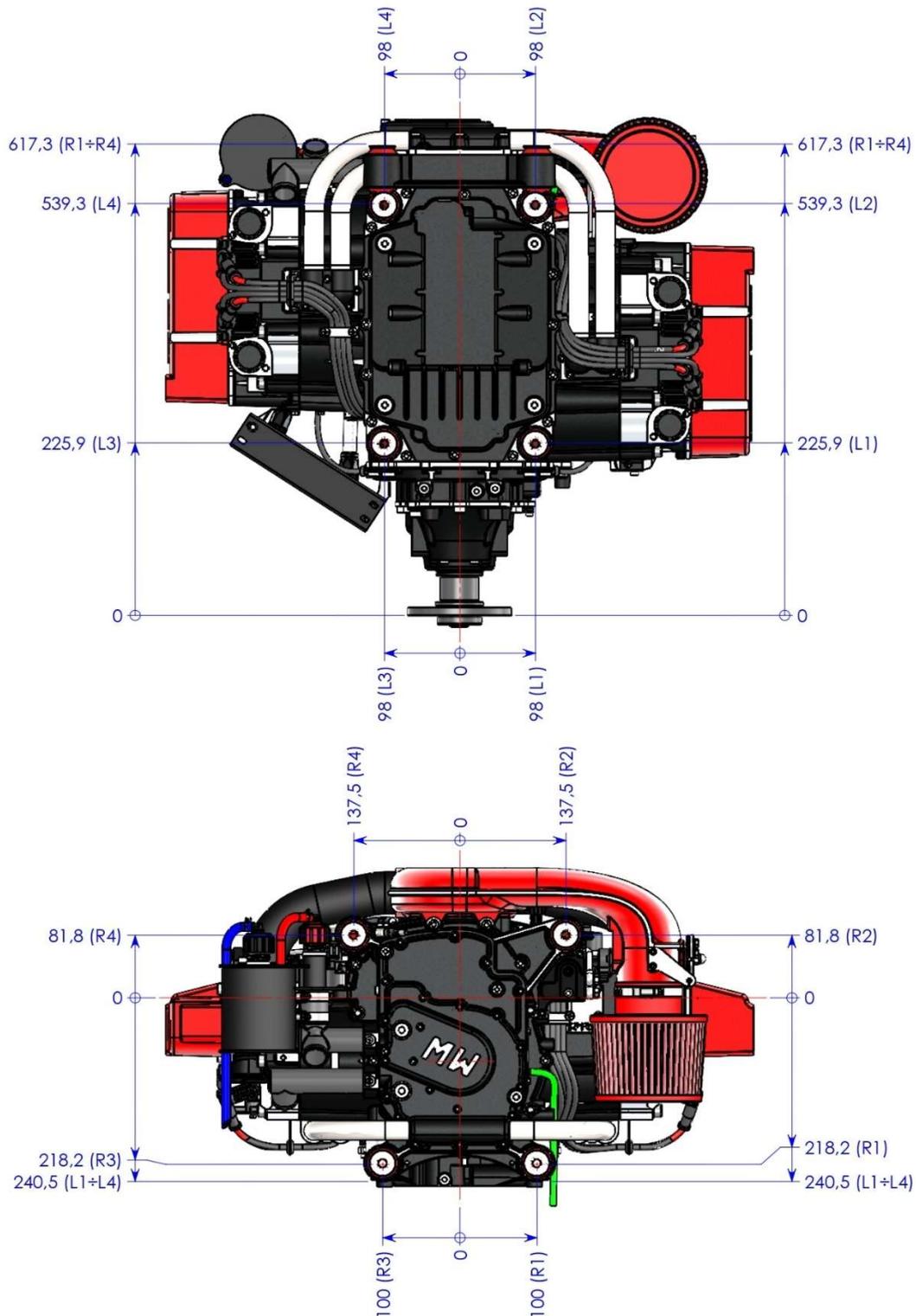
If the fixing points R are used, the design of the engine mount must consider the compliance of the anti-vibration damper: as a consequence, the engine undergoes a downward inclination of about 1 degree, corresponding to a displacement of the propeller flange of about 10 mm down.

## ATTACHMENT POINT DIRECT VERSION



10-01-P

## ATTACHMENT POINT DSRII VERSION



10-02-P

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### 10-02-02 Permitted Deviation Angles

To enable appropriate operation of the engine lubrication circuit, it is necessary during installation and in flight, to observe the following table, which specifies the maximum angles on the ground and in flight of the engine with respect to a horizontal plane.

The symbol – placed before pitch angle denotes a propeller angle below the horizontal line, the symbol + on the upper side, the symbol - in front of the roll angle defines angles that rotate cylinder bank 1 upward, the symbol + at angles that lead it downward.

The table below refers to an engine used on a tractor configuration and shows the values determined by the minimum (2,8 litres) and maximum (3,55 litres) oil level.

<b>All Versions</b>			
Maximum angle of rotation [deg]	<i>On ground</i>	<i>In flight</i>	
		<i>Min</i>	<i>Max</i>
<i>Pitch axis</i>	+15/-5	+45/-10	+45/-18
<i>Bank angle</i>	+10/-10	+30/-30	+40/-40

10-07-C



**Exceeding deviation angles specified above can cause great danger.  
Never position the engine in a manner different from the one prescribed above.**

### 10-02-03 Position of Fixing Points for Accessories

On the gearbox there are various holes, called "G", for fixing accessories or the pre-rotation mechanism of the gyros: all these holes have a M8X1.25 thread, with a minimum useful length of 12mm. In addition to these holes, the holes called "E" can be used for the same purpose, with M10x1.5 thread and a minimum useful length of 20mm, designed for the union between crankcase and gearbox (PSRU versions) or between crankcase and front cover (Direct versions).

On the Direct versions the only holes available for fixing accessories are the "E" type holes.



It is not possible to use any point other than those indicated for fixing accessories or mechanisms.



The tightening torque of the "G" screws is at the discretion of the installer: however, it must not exempt the value of 22 Nm. The tightening torque for the "E" screws must be 35nm and a medium threadlocker compound must be applied on them.

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In the case of use of "E" point, it is necessary to interpose between hole and accessory special bushings with external diameter 18mm and 10mm height, to ensure that the tightening takes place between planes.

The coordinates of the fixing points are shown in the following table: The value in square brackets [] refers to Direct type engines.

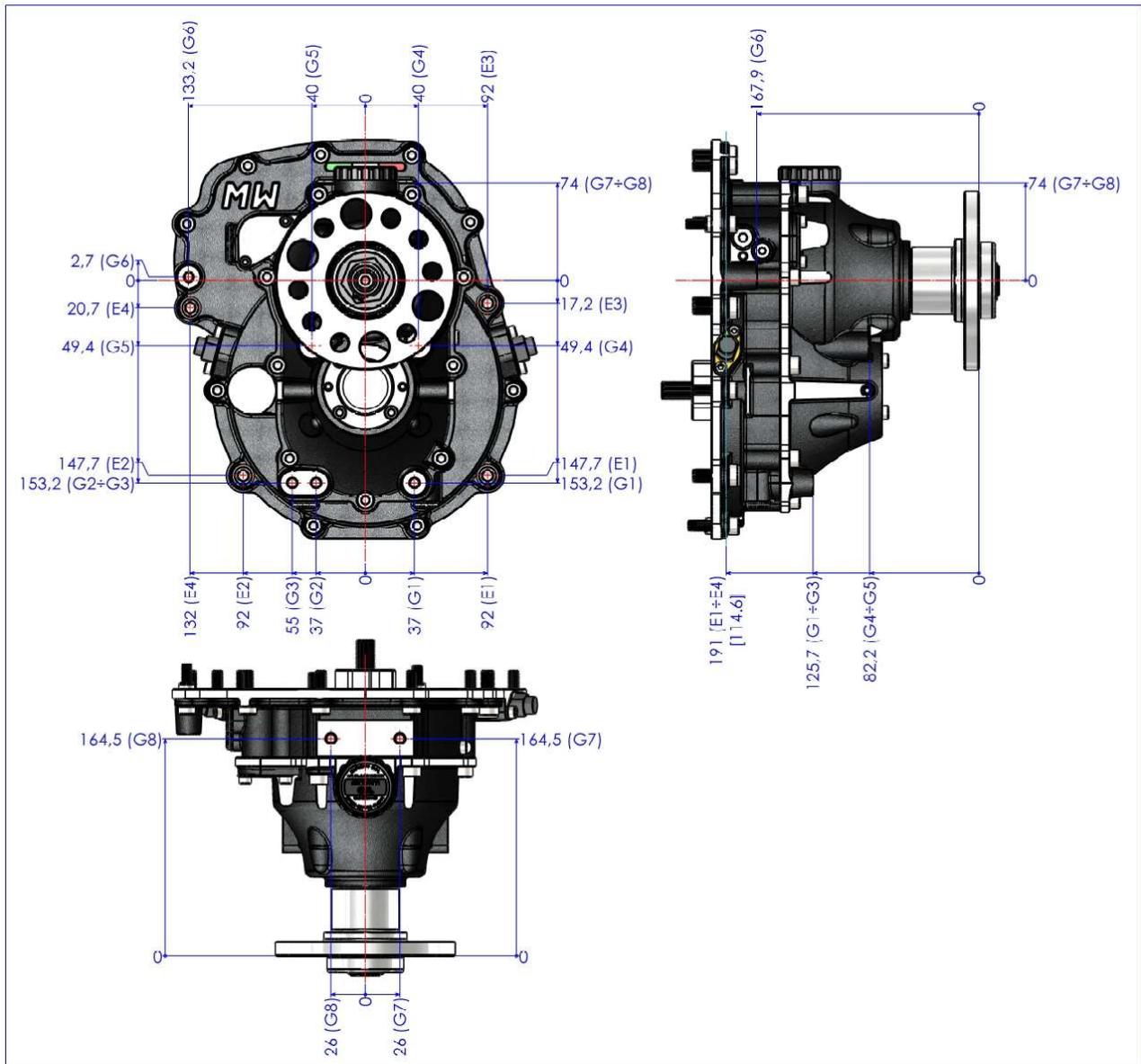
<b>Coordinates of Accessory Attachment Points</b>			
	X	Y	Z
<i>E1</i>	191 [114,6]	-92	-147,7
<i>E2</i>	191 [114,6]	92	-147,7
<i>E3</i>	191 [114,6]	-92	-17,2
<i>E4</i>	191 [114,6]	132	-20,4
<i>G1</i>	125,7	-37	-153,2
<i>G2</i>	125,7	37	-153,2
<i>G3</i>	125,7	55	-153,2
<i>G4</i>	82,2	-40	-49,4
<i>G5</i>	82,2	40	-49,4
<i>G6</i>	167,9	133,2	2,7
<i>G7</i>	164,5	-26	74
<i>G8</i>	164,5	26	74

10-08-C



On the PSRU versions, use the "G" point preferably.

The following drawing shows the quotas of the fixing holes accessories on the engine; Also, in this case, the value between square brackets [] refers to Direct type engines.



10-03-P

### 10-02-04 Maximum Load Permitted on the Attachment Point

Each mounting point can be subjected, during operation, to a maximum load that does not exceed that specified below. The engine frame must therefore be designed in such a way as to distribute the load of force resulting from contingency conditions of the aircraft, having care during the design and tuning stage to be in compliance with operating limits below.



The engine mount should be designed to not exceed the max allowable load on the attaching point.

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### "R" Engine Attachment Points

To attach the engine, use only M10x1.5 class 8.8 bolts, partial threaded (shank) minimum length 70 mm plus the length of mounting point on the engine frame. The measurement is rounded up. For tightening of each screw, it is recommended to use a plane nut overlapping and self-locking nut (nut and locknut). Alternatively use screws with transverse hole for the insertion of a safety split pin.

The max allowable load on each R attachment point is:

- In X direction 9000 N
- In Y direction 40000 N
- In Z direction 22000 N

In case of a multi-directional load, the max allowable load is fixed by the vectorial combination of the above load. Those maximum loads cause elastic deformation. Considering that the material of the attaching point has a small plastic deformation range (less than 5%) it is mandatory to respect the above limit.

In the case of uniform distribution of the load on the rear 4 points, the same are able to withstand without permanent deformation an inertial load up to 6 G, supposed applied independently in each of the three main directions to the centre of gravity of the engine, with a safety factor equal to 2; in the case of cargo, that is the result of the vector composition of the same.

### "L" Engine Attachment Points

To attach the engine, use only M10x1.5 class 8.8 bolts, partial threaded (shank) minimum length 70 mm plus the thickness of mounting point on the engine frame. The length is rounded up. For tightening each screw, it is recommended to use a plane nut superimposed by a self-locking nut (nut and nut). Alternatively, use screws with a transverse hole, special nut and cotter pin.

The adapters (code S039), prepared to house the damper, should be screwed into the engine at the 4 lower corners of the engine crank case using the screws supplied with the adapter at a tightening torque of 22Nm and using a medium threadlocker.

The max allowable load on each "L" attachment point is:

- In X direction 7500 N
- In Y direction 7500 N
- In Z direction 3000 N

In case of multi-directional load, the max allowable load is fixed by the vectorial combination of the above load. Those maximum loads cause elastic deformation. Considering that the material of the attaching point has a small plastic deformation range (less than 5%) it is mandatory to respect the above limit.

In the case of uniform distribution of the load on the rear 4 points, the same are able to withstand without permanent deformation an inertial load up to 6 G, supposed applied independently in each of the three main directions to the centre of gravity of the engine, with a safety factor equal to 2; in the case of combined loads, the load is the of the vector composition.

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### "F" Engine Attachment Points

To attach the engine, use only M10x1.5 class 8.8 screws, partial threaded minimum length 40 mm plus the thickness of fixing point on the engine frame.

The max allowable load on each F attachment point is:

- In X direction 15000 N
- In Y direction 10000 N
- In Z direction 15000 N

In case of multi-directional load, the max allowable load is fixed by the vectorial combination of the above load. Those maximum loads cause elastic deformation. Considering that the material of the attaching point has a small plastic deformation range (less than 5%) it is mandatory to respect the above limit.



Using the F attachment point it is mandatory to use a damping element between the engine and the engine frame to prevent stressing the aircraft frame with excessive vibration.

### "E" Accessories Attachment Points

For tightening, use only M10x1.5 class 8.8 screws, with partial threaded and minimum length of 35 mm increased by the thickness of the accessory.

The maximum allowable load on points and is:

- In X direction 15000 N
- In Y direction 5000 N
- In Z direction 5000 N

In case of multi-directional load, the max allowable is the vector composition of the three above limit.

### "G1÷G3" and "G6" Accessories Attachment Points

For tightening, use only M8x1.25 class 8.8 screws, with partial threaded and minimum length of 12mm increased by the thickness of the accessory.

The maximum allowable load on points and is:

- In X direction 5000 N
- In Y direction 2000 N
- In Z direction 2000 N

In case of multi-directional load, the max allowable is the vector composition of the three above limit.

### "G4÷G5" Accessories Attachment Points

For tightening, use only M8x1.25 class 8.8 screws, with partial threaded and minimum length of 12mm increased by the thickness of the accessory.

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The maximum allowable load on points and is:

- In X direction 8000 N
- In Y direction 8000 N
- In Z direction 8000 N

In case of multi-directional load, the max allowable is the vector composition of the three above limit.

#### "G7÷G8" Accessories Attachment Points

For tightening, use only M8x1.25 class 8.8 screws, with partial threaded and minimum length of 12mm increased by the thickness of the accessory.

The maximum allowable load on points and is:

- In X direction 10000 N
- In Y direction 10000 N
- In Z direction 15000 N

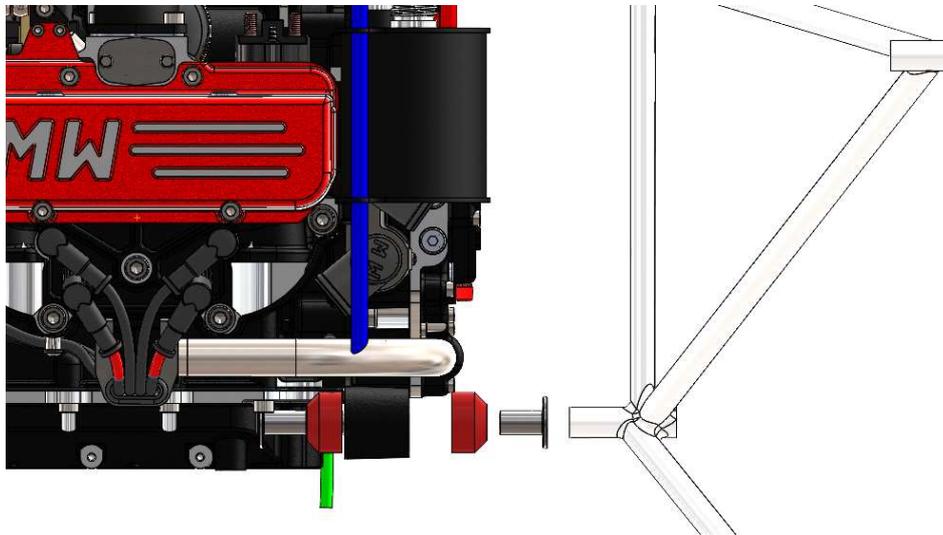
In case of multi-directional load, the max allowable is the vector composition of the three above limit.

### **10-03-00 Attachment on Engine Frame**

The installation of the engine must be done as described below.

#### Necessary Tools and Materials

1. Torque wrench 20÷100 Nm
2. T handle allen key 6mm
3. Hex wrench 17 mm
4. Special hook to lift the engine cod. X299
5. Crane to lift the engine with at least a maximum load >150 Kg
6. Medium threadblock
7. Vaseline grease
8. General tools according to the installation

*10-04-P*

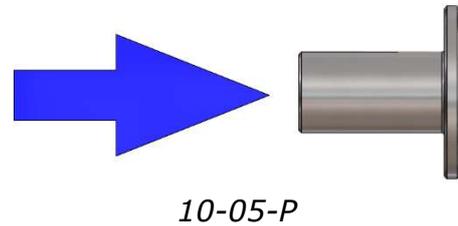
- a.** Mount [2] the lifting tool [4] on the engine. Alternatively, provide a system for lifting the engine, making sure that no parts of the wiring, the spark plug cables or the spark plugs themselves are stressed during the operations.
- b.** To lift the engine with the crane, position the crane [5] close to the engine frame and adjust the high of the crane to align the attachment points on the engine to the corresponding attachment points on the engine frame. In bed mounting align the engine 2 cm above the engine frame.
- c.** Insert the dampers into the attachment points on the engine, to ease this operation it is better to spread Vaseline grease [7] on the dampers.
- d.** Insert the spacer in the damper: use Vaseline grease [7] to ease this operation.
- e.** Insert the four fixing screws in the holes in the engine mount and on the engine mounts.
- f.** Screw [3] the four bolts to align and pull the engine closer to the engine frame. While turning ensure that the dampers stays inside their housings in the attachment points
- g.** Gradually tighten the four screws up to the tightening torque indicated by the air frame manufacturer (normally between 35 and 45 Nm) using threadlocker [6].
- h.** Remove [2] the special hook [4] from the engine .

**A**

The dampers are made of a plastic material. They are perishable and sensitive to atmospheric and chemical agents and to temperature. Check the condition of the dampers regularly and replace them at time interval indicated in the maintenance manual or at any appearance of damage.

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The standard pre-load on each damper is 0.5 mm. To increase the stiffness of the engine installation, it is necessary to machine down a small quantity on the side indicated in picture



### 10-04-00 Installation Verification Test

After completing the installation of the engine, all its components and instrumentation and before flying, a test must be performed on the ground to verify the adequacy of the mountings and correct operation within the operating limits of the engine.



Before starting the engine for the first time, it is necessary to carefully read the operating manual in its entirety.

Before starting the engine, make sure you have filled the cooling system and the required oil supplies.

The engine test is an essential phase of installation: it must therefore be approached with caution and attention to any signal that may indicate operating anomalies or defects in the installation. In case of doubts about the actual functionality and safety, do not fly or continue the test before having improved the installation or removed the cause of any anomalies.



**Never run the engine indoors. Exhaust gases contain carbon monoxide, a particularly poisonous gas, which, if inhaled in excessive quantities, rapidly leads to unconsciousness and death.**



**On the ground, in the presence of observers, use the engine carefully and make sure you have a complete view of the danger area.**



**Never leave the aircraft while the engine is running.**



**In the event that faults or discrepancies from the normal operating condition described occur during the pre-flight tests, do not continue with the test, nor use the engine in flight before having identified and resolved the cause.**



Before starting the engine, make sure that each component of the engine is firmly fixed, so as to prevent it from being accidentally lost in flight.

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Do not start the engine without the propeller: this can cause serious damage.

Prepare the engine as follows.

- a.** Check in advance that the instrumentation is functioning properly and that all installations are correctly completed and the components are fixed.
- b.** Be sure that the battery is fully charged.
- c.** Ask the help of a second person who will stay on the ground away from the aircraft and propeller in a safe area.
  - d.** Equip them with a fire extinguisher suitable for fuels. The fire extinguisher will be kept and used by the person who will help you on ground. You must carefully read the instructions for the extinguisher.
  - e.** Prepare the tools needed to purge the cooling system
- f.** Move the aircraft in an open space.
  - g.** Place it away from any obstacles that may impact on the propeller or on the aircraft.
  - h.** Stop the aircraft by placing a pair of chocks on each main landing gear wheels.
  - i.** Before starting the engine verify the fuel pressure system is working in accordance with the requirements indicated.

#### 10-04-01 *First Start-up*

Only for the first start-up of the engine it is necessary to follow all the below instructions:

- a.** Switch on the master relay to power on the electrical system.
- b.** Switch on the instrumentation.
- c.** Check that the sensor values on your instrumentation are coherent.
- d.** With both ECUs switched off, make the engine run 5 sec using engine starter. That helps to arm the oil pump.
- e.** Purge the fuel circuit.
- f.** Switch on the main ECU.
- g.** Try to start the engine keeping the throttle in the idle position: normally the engine will start within two tries. If the engine does not start in two tries it could be an electrical problem or a problem in the fuel line.



In case of a prolonged stop of the engine, it is necessary to check the correct operation of the injectors: in fact, they could be blocked by fuel residue, making starting difficult or impossible.

- h.** When the engine starts, it automatically goes to 1300 RPM, and then (after about 5 seconds) the RPM rises and goes between 1700 and 2300 RPM. It is possible that at the first start-up of the engine it will stay at the lower RPM with

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an excessive vibration. In this case, help the engine by opening the throttle just a little and then bring throttle back to idle position.

**i.** Verify that the oil pressure rises over 1.0 bar within 5 seconds after the engine start: if it does not rise, stop the engine and find and resolve the reason for the problem.

**j.** Keep the throttle in idle position and complete a warm up cycle, verify that oil temperature and coolant temperature rise gradually. When the temperature of the engine has reached the operating value (coolant temperature 72°C and oil temperature 50°C) the engine will automatically decrease to about 1200 RPM.



In the event that the accelerator lever is not set to the minimum position, the starting procedure will not be carried out and the engine will operate irregularly.

**k.** Slowly open the throttle and bring the engine regime up to 3200RPM and then put the throttle back to the idle position, repeat that operation three or four times. That operation helps to eliminate the air from the coolant circuit.

**l.** Turn off the engine and proceed to purge the coolant circuit.

**m.** Start the engine and bring it to 2700 RPM, this time use both ECUs to start the engine.

**n.** At the regime, switch on the secondary pump to check it and to check if the fuel circuit has the correct the fuel pressure which should not change by more than 0.4 bar. If the change is greater than that then the dimensions of the fuel circuit tube is not correct. Modify the tube or the fuel line.

**o.** Switch off the auxiliary ECU: no significant regime change should happen.

**p.** Switch on the auxiliary ECU and turn off the main ECU. You may feel a slight change in regime initially after which the system is set to the initial value. Turn on the main unit.

**q.** Switch off the master switch to disconnect the battery from the electrical system: The engine should continue to run without any anomalies or irregularities. It is possible to see a small increase in voltage on the voltmeter gauge, usually less than 0.2-0.3 volts. If the engine stops or begins to run unevenly, you should carefully check the wiring harness pay particular attention to the capacitor connections.

**r.** Reconnect the battery to the electrical system, reactivating the master relay, bring the engine to idle and check that it remains regular and without producing excessive vibrations: in the event of anomalies, it is necessary to check the installation of the accelerator cable.

**s.** With the engine at idle, switch off the auxiliary control unit: there should be no speed variation; turn the auxiliary control unit back on and turn off the main control unit: in this case the idle speed must rise up to about 1700 rpm.

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Increasing the idle speed prevents unwanted engine shutdown in the event of the battery disconnected from the system.

**t.** When the engine is warmed up, turn it off and the start it up again. Turning off and starting up should happen without vibrating and jamming.

**u.** Try to start the engine with one ECU per time, try with primary ECU and then with the auxiliary ECU, in both cases the starting up should happen without problem.



Starting the engine with only the auxiliary control unit is deliberately only possible when the engine is warm.

**v.** When the engine is turned off, check that there is no leakage of coolant or oil. In case there is a leakage of coolant or oil find the origin.



In the first hours of operation there can be a slight blowby of refrigerant or, more rarely, of lubricant from the drainage tube placed in the rear of the engine on side #1. This is normal and is caused by settling of the mechanical seal and oil seal.

#### 10-04-02 Verification and Validation

The installation tests have two different goals. To look for problem connected to the engine but also to perform the trial stage for the mechanical components of the engine: only after the installation tests is the engine ready to guarantee the maximum performance. After 15 operative hours, the engine is considered to be run in.



During the test it is important to continue to check the engine temperature and pressure parameter, stopping the test if any anomaly occurs.

#### Ground Test

Each engine is built and assembled using high precision components and procedures. After assembly each engine is subjected to a cycle of tests necessary to evaluate the compliance with the project requirements and to enable a gradual breaking in of the mechanical components. Even though it is not strictly required, it is good practice to test a new engine on the ground after installation to verify that the installation is complete and highlight the any defects that would cause safety issues-Follow the procedure below:

**a.** Mount the cowling.

**b.** Start up the engine (A.17.3.) and frequently change the regime of engine keeping it under 3000 RPM; keep checking coolant temperature, oil temperature. These parameters should pass the admitted limits. This test can be done in both a fixed-point condition or in a taxi condition.

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- c. At the end of any test check for the total absence of any coolant or oil leakage, the total absence of any sign of overheating in any components inside the cowling and the total absence of any sign of friction or stretching off the wire harness or on the fuel line (due to the engine vibration).

The ground test should last at least half an hour, or longer, depending on the complexity of the installation.



**On the ground avoid to running the engine over 3200rpm for more than 1 minute since the cooling flow may be inadequate and cause a failure in engine component.**

### Max Power Test

Before executing the first flight, it is advisable to check that the engine can deliver the maximum power in order to avoid dangerous situations in the first take off. The verification must take place by adjusting (only for variable pitch propeller) the propeller at the pitch angle indicated by the manufacturer and checking if the max rpm of the engine is in compliance with the rpm indicated by the propeller manufacturer. This value should be within a tolerance of approximately 5%, which means, a power deliver tolerance of 15%. The fact that the pitch measurement of the blade is quite difficult and may be inaccurate and therefore even small variations of the angle may cause large power variations as a function of propeller profile. The test is performed once the engine has completed the warm up phase and must be repeated three times. The first with both ECU's switched on, the second with only ECU A switched on and the third with only ECU B switched on. It is also important to check the variations in maximum engine rpm when the second fuel pump is turned on as this is a sign that the fuel system is not properly tuned. A final test should be done with a full electrical load on the aircraft.



It is normal that after the first 15 hours of use of the engine the maximum RPM should increase because all mechanical components, at this point, are run in. It is possible that the first maximum power test, completed after the ground test, can give a maximum power result lower than the expected one, or respect an engine already run in.

### Flight Test

After completing the previous steps, it is recommended, for the first 10 hours of flight, to limit running the engine at max rpm at take off only and for a period no longer than 60 seconds. Similarly, if using a variable pitch propeller avoid keeping the propeller at max pitch for a long period as this could thermodynamically stress the engine. Instead use a propeller setting less stressful to the engine. The table below indicates the main precautions to follow in the first 15 hours of flight.

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<b>Main caution for the first 15 hours of flight</b>	
RPM	Keep the engine at maximum RPM within 60 seconds, and only in take off condition In flight condition keep the engine at least 300 RPM under the max continuous power with MAP lower than 26 inHg
Oil Temperature	Keep under 110 °C
Coolant temperature	Keep under 95 °C
MAP	For the flight condition set the propeller pitch (if possible) to have engine running with high RPM with and low value of MAP
Type of flying for test	Do short flight , with frequent take off and landing

*10-09-C*



**The above caution for the first 15 hours of flight should not be limiting in respect to flight safety: so, in case of emergency, feel free to use the engine at the maximum power for all the time it is necessary and use a setting of the propeller that is different from the one suggested. In case of emergency feel free to use the engine as you need.**

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## 21-00-00 AIR CONDITIONING

### 21-40-00 Cabin Heating Circuit

The cabin can be heated by using the engine coolant and by providing a suitable radiator at the inlet of the cabin ventilation air intake. In the rear part of the engine, on the cooling pump cover, there are the predispositions for the connection of the delivery and return pipes of the heating fluid to the cab radiator.



The point of withdrawal of the coolant is upstream of the thermostatic valve, so that the heating will start working from the first moments after the engine is started.

#### 21-40-01 Characteristics of the Components

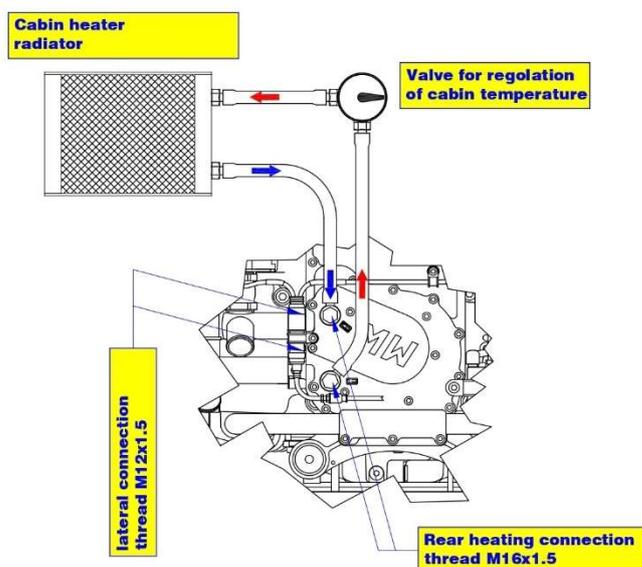
- Rear heating connection thread M16x1.5
- Side heating connection thread M12x1.5
- Typical internal diameter of heating pipes 10mm
- Maximum length of heating pipes 2x500mm
- Typical heating radiator area 300 cm<sup>2</sup>
- The radiator must have a vent hole in the upper part



With a correctly sized ventilation air intake, the cab heating is sufficient even at low speeds and in cold climates. To increase the effectiveness of the system it is possible to equip the radiator with an electric fan.

#### 21-40-02 Criteria for the Construction of the Cabin Heating Circuit

The system must be made according to the scheme of the following figure.



21-01-P

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### Necessary Materials

1. Torque wrench 50 Nm
2. 6 mm Allen key
3. 8 mm Allen key
4. Tools according to the products to be installed

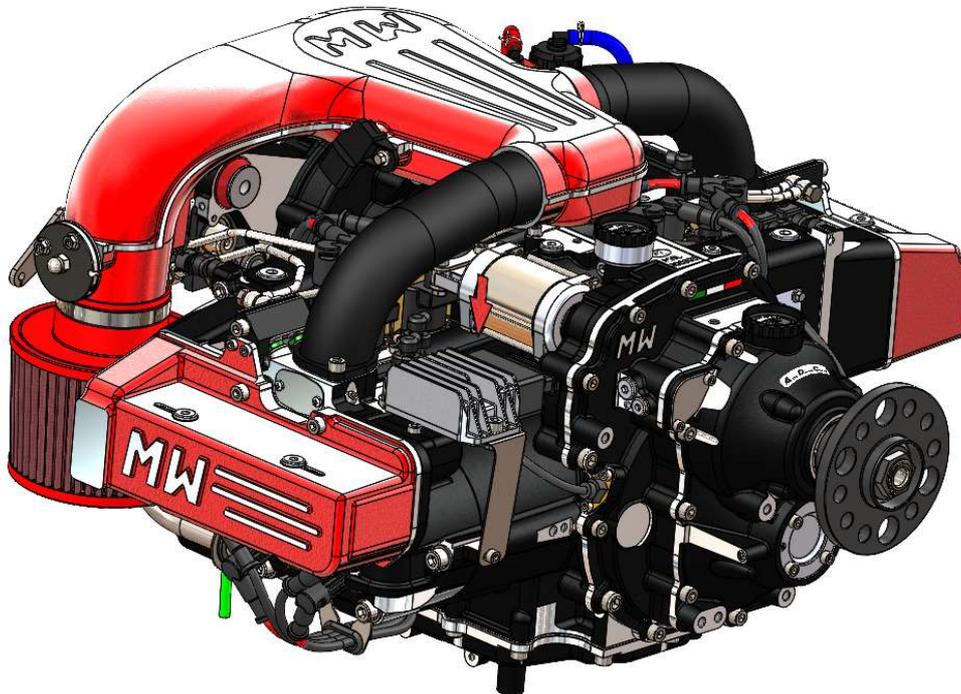
The heating radiator must be installed as close as possible to the engine, preferably in the engine compartment itself: this is to interfere as little as possible with the correct functioning of the cooling system. To regulate the temperature in the cabin, it is necessary to provide a valve on the radiator fluid delivery branch: the same valve must be able to completely close the flow to the radiator if hot air is not desired in the cabin. Drain the cooling system if it is already filled.

- a.** Remove [3] the plugs from the two M16x1.5 pre-setting holes, located in the rear part of the engine. Alternatively, it is possible to use the side predispositions (thread M12x1.5): the caps must in any case be removed [2].
- b.** Secure the radiator [4].
- c.** Make the connections between the radiator and the engine, paying attention not to reverse the flow direction. The rear fittings must be tightened [1 + 4] to 30 Nm; the side fittings must be tightened [1 + 4] to 18 Nm.
- d.** Fill the system, taking care to eliminate the air also from the heating radiator.

**24-00-00 ELECTRICAL POWER****24-30-00 Main Recharge System**

The engine is equipped with a direct current recharging system, consisting of a permanent magnet generator and a current regulator associated with it: the connection between the regulator and the generator is already made; the connection between the regulator and the engine electrical system is also already made. By respecting the attached wiring diagram, the engine will be able to operate regularly, both with a generator failure and with a battery failure. In the first case the autonomy is between 10 and 50 minutes, depending on the capacity of the battery installed and the power consumption of the electrical devices; in the second case the autonomy is unlimited, but the engine must operate above 1500 rpm. A good practice, in both cases, is to land as soon as possible to repair the failure. In particular a prolonged operation of the voltage regulator without a battery connected can damage it: after events of this type it is necessary to check the integrity of the regulator.

The voltage regulator is fixed to the engine with two screws in such a way as to be grounded.



24-01-P



Do not start the engine with the voltage regulator disconnected: this can seriously damage the regulator and the generator, which then must absolutely be checked and replaced if necessary.

**A**

A possible failure of the generator does not affect the operation of the engine but limits the autonomy: if the electric system is done according to diagram.

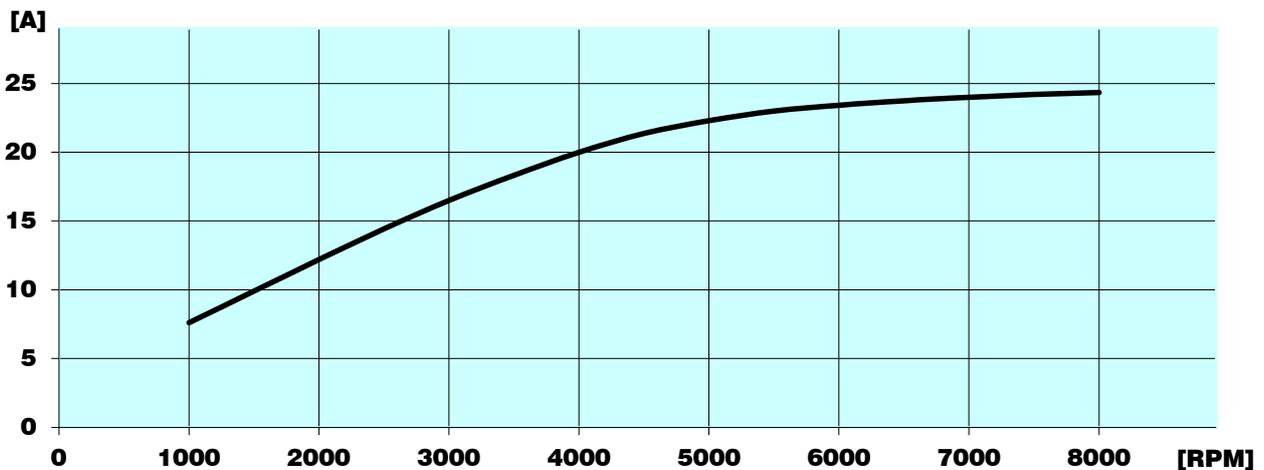
**24-30-01 Internal Generator Features**

- Internal rotor with permanent magnet and counterphase windings
- Nominal recharge voltage 14 V
- Max recharge current 24 A
- Nominal recharge power 300 W
- Recharge power at 1000 rpm 95 W
- Recharge power at 4200 rpm 250 W
- Max operating temperature 130 °C
- Weight 2000 g



24-02-P

The following figure shows the charging curve as a function of rpm, measured with a constant charging voltage of 12.5 V and generator at 20 ° C temperature.



24-01-C

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The normal operating temperature of the generator is similar to the engine oil temperature (~ 100 ° C): at 90° the performance of the generator is at least 15% lower than that shown in the graph.



In case the engine is running with the generator disconnected from the voltage regulator, it may be necessary to replace the generator.

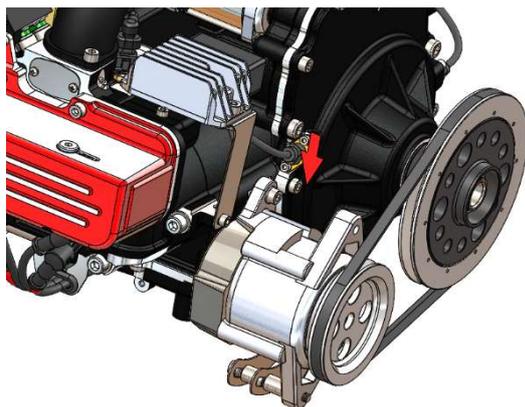
### 24-30-02 Voltage Regulator Features

▪ Type of bridge	antiphase
▪ Nominal recharge voltage	>14 V
▪ Max recharge current	26 A
▪ Breaker	30 A
▪ Max operating temperature in flight	75 °C
▪ Minimum operating temperature in flight	-20 °C
▪ Standard operating temperature in flight	40 °C
▪ Max temperature (not in use)	110 °C
▪ Weight	290 g

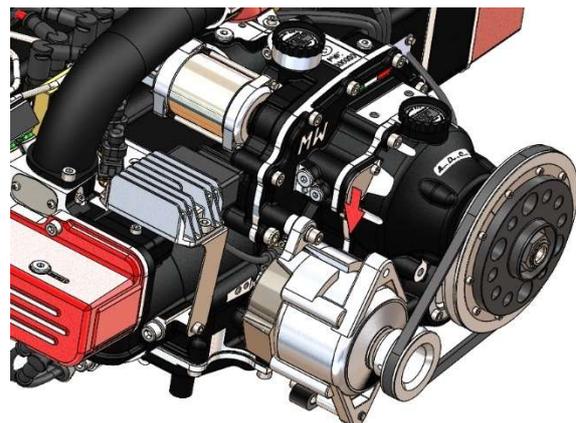
The above characteristics are related to the optimal cooling conditions of the voltage regulator.

### 24-31-00 Auxiliary Generator Module (AG-m)

All engines, both in the direct version and in the version with gearbox, are designed for the attachment of an auxiliary generator with stator with wound fields: in both cases the auxiliary generator is housed in the front part of the motor, bank side # 1



24-03-P



24-04-P

If the auxiliary generator is used, it is advisable to install a second battery for the on-board systems, recharged, through an independent circuit, by the auxiliary generator itself: using a "cross switch", it is possible to connect the two circuits in case of emergency on one of the two generators.

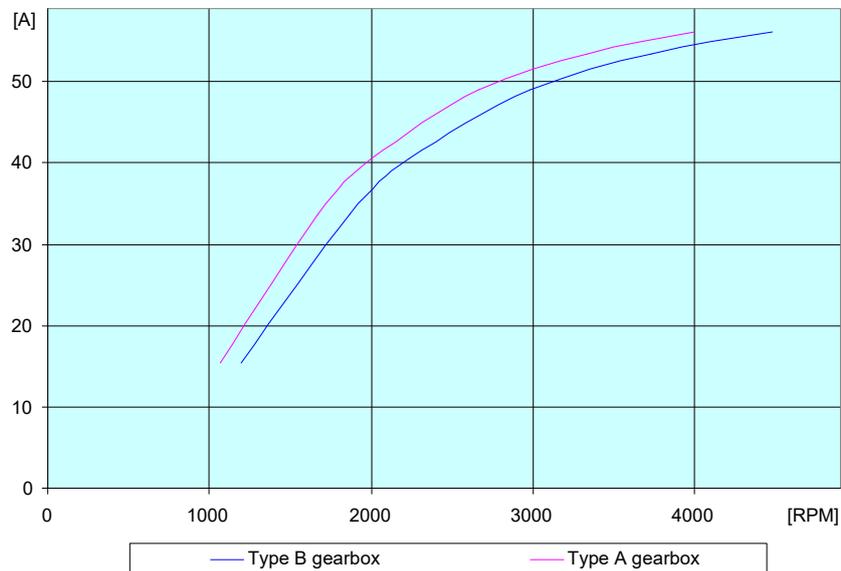
**24-31-01 Generator Features**

▪ Nominal recharge voltage	13.8 V
▪ Max recharge current	56 A
▪ Recharge power at 1200 rpm (at 13.5V, version with gearbox B)	e200 W
▪ Recharge power at 4200 rpm (at 13.5V, version with gearbox B)	740 W
▪ Breaker	80 A
▪ Max operating temperature	80 °C
▪ Max rpm	6300 RPM
▪ Generator weight	3050 g
▪ Accessory and bracket weight	1030 g
▪ Total weight	4080 g



24-05-P

The following figure shows the recharge curves as a function of the engine revolutions, for the versions with type A reducer and for the versions with type B reducer: the curves are measured with a constant charge voltage equal to 13.5 V and generator at 20 ° C.

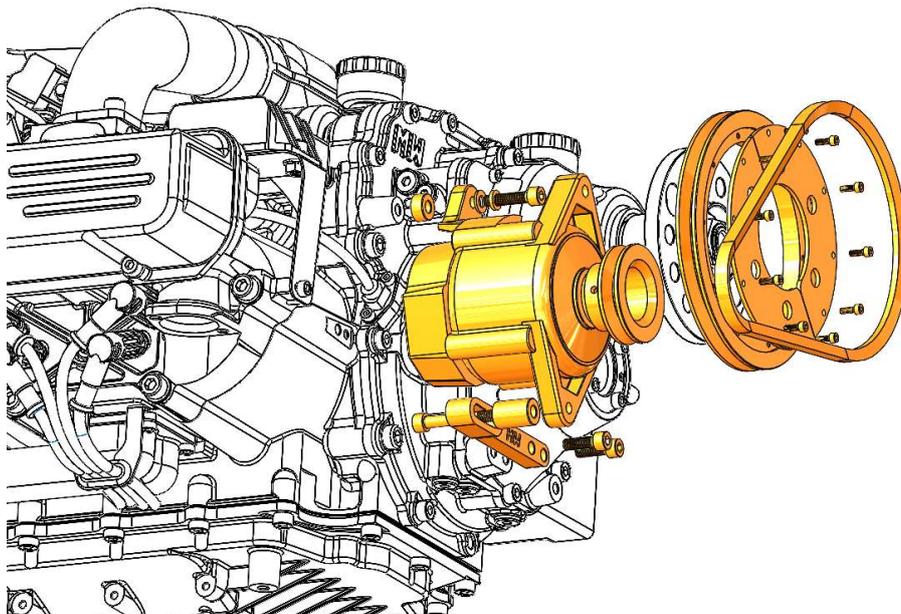


24-09-C

### 24-31-01 Installation

All parts necessary for installation are supplied together with the AG-m.

The following refers to the assembly of the kit for motors equipped with gearbox: the assembly of the kit on direct motors has some differences with respect to what is reported.



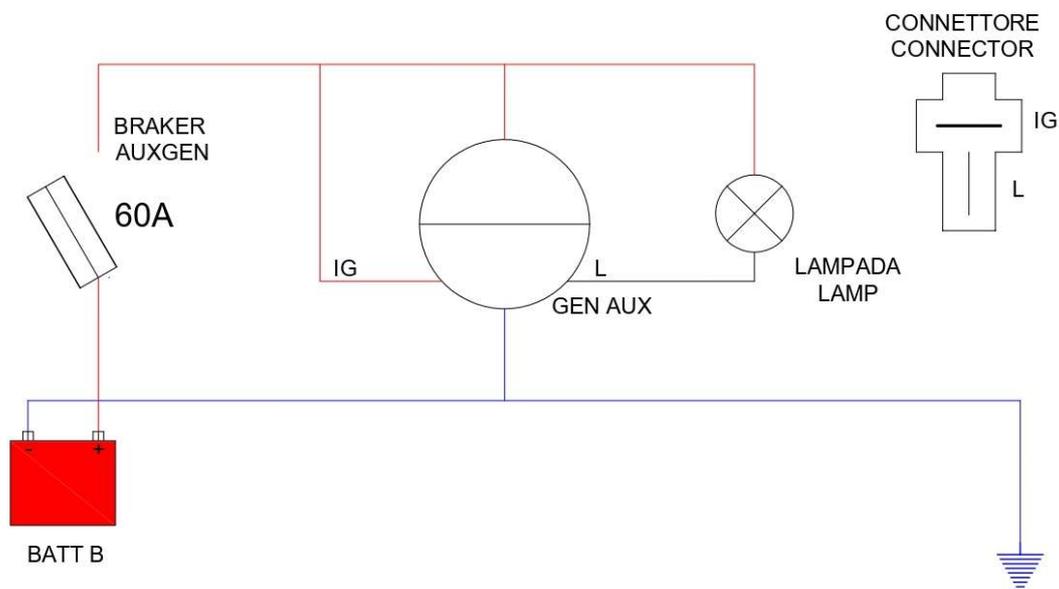
24-06-P

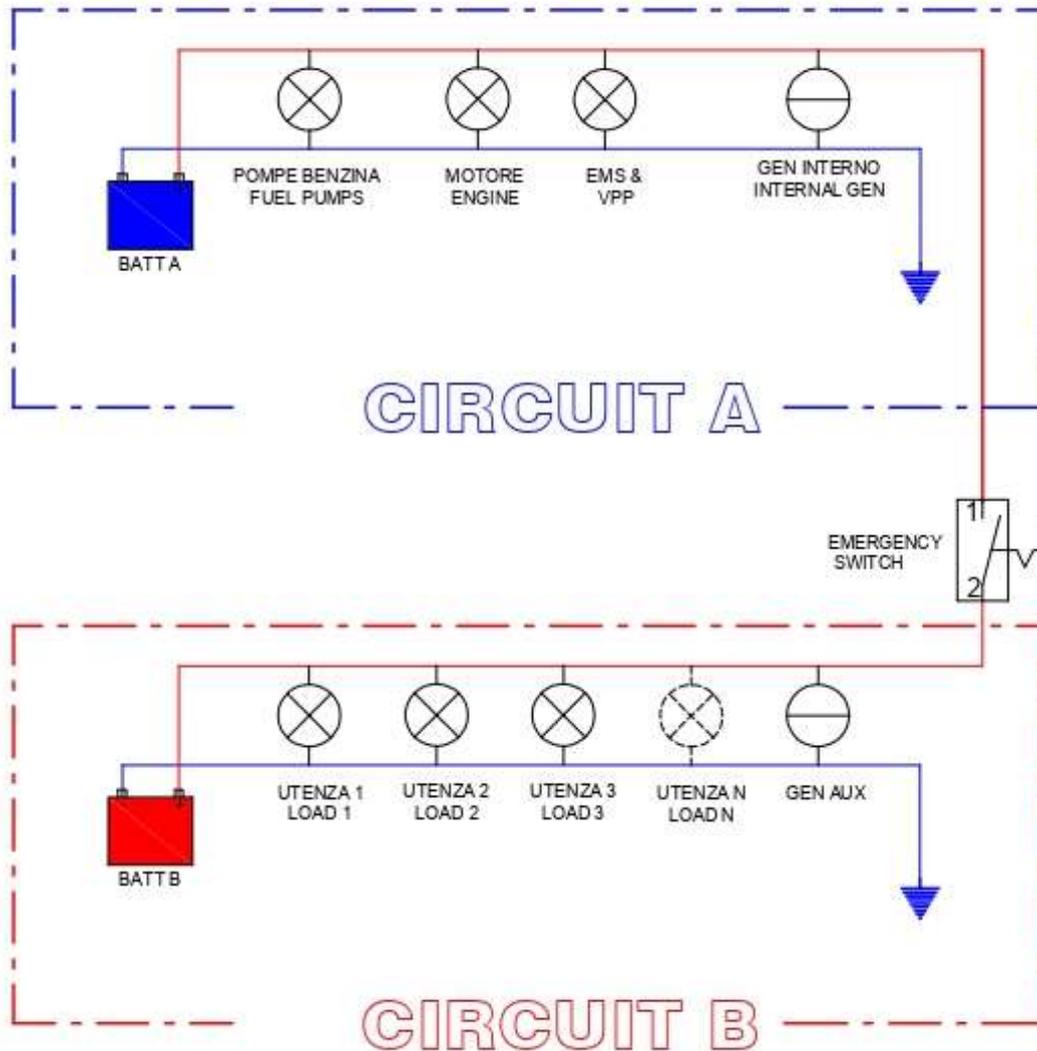
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### Necessary Materials

1. Torque wrench 1÷10 Nm
  2. Torque wrench 20÷100 Nm
  3. Allen key 3 mm
  4. Allen key 6 mm
  5. Open end wrench 13 mm
  6. Medium threadlocker
  7. Keys in relation to the type of propeller mounted
    - a.** Remove the propeller [7].
    - b.** Insert the generator drive pulley on the propeller flange, taking care to keep the side of the pulley with the reduced diameter for housing the fixing half-moons in the front position.
    - c.** Screw [3; 6] the two fixing half-moons to the pulley: they are identical and have no preferential mounting direction; tighten [1 + 3] to 3 Nm.
    - d.** Screw [4; 6] the tensioning rod of the auxiliary generator to the front part of the gearbox, interposing the washers provided, using the shorter M8 screws; tighten [4 + 2] to 25Nm.
    - e.** Fit the supplied drive belt onto the groove of the drive pulley.
    - f.** Fit the propeller onto the flange and hold it in place.
    - g.** Approach the drive pulley to the rear part of the propeller flange, taking care to align the holes for the fixing screws with those on the flange.
    - h.** Depending on the type of propeller fixing used:
      - with ARP502 type fixing insert the 6 1/2 "screws in the rear part of the drive pulley, fit the propeller on the flange and tighten [7 + 2] the fixing screws according to the specifications of the propeller manufacturer;
      - alternatively, insert the six drive columns D13 mm in the rear part of the drive pulley in such a way as to insert them fully even in the holes provided on the propeller; insert the six fixing screws into the columns, fit the propeller on the flange and tighten [7 + 2] according to the specifications of the propeller manufacturer.
- The drive pulley must be screwed to the propeller flange by means of the same tightening screws as the propeller.
- i.** Insert the medium length M8 screw on the rear upper connection of the generator; insert the lower spacer of the two supplied on the screw.
  - j.** Screw [4; 6] the screw to the upper hub on the gearbox, without tightening.
  - k.** Insert the longer M8 screw supplied in the rear part of the tensioning rod, interposing the washer.
  - l.** Screw [5; 6] the screw to the generator, without tightening.
  - m.** Fit the drive belt on the generator pulley.

- n.** Tension the transmission belt by moving the generator outwards: a correct tension is the one that allows the belt to have a maximum deflection of about 8 mm in the intermediate part.
- o.** Once the correct tension has been found, tighten [4 + 2] the upper screw of the generator and then [5 + 2] also the lower one; for both the prescribed torque is 22 Nm.
- p.** Screw [5] the supplied nut to the protruding part of the lower screw, and tighten [5 + 2] to 22 Nm keeping the screw in position with a second wrench.
- q.** Make the electrical connections as shown in diagram **24-03-C** and **24-04-C**. The auxiliary generator must be connected to an auxiliary battery which will power an electrical circuit (called circuit B) to which various electrical users of the aircraft will be connected. The main battery will be connected to the electrical circuit (called electrical circuit A) to which the electrical circuit of the engine, the petrol pumps, and the internal generator must be connected. The two electrical circuits can be connected by means of a suitable switch in case of battery or generator failure of circuit A.

**24-03-C**



24-04-C

**A**

The direct connection of the auxiliary generator on the circuit of the internal generator could cause a failure of the latter.

**A**

Periodically it is necessary to check the tension and the state of use of the transmission belt.

**61-00-00 TRANSMISSION**

**SPIRIT** engines are available in direct version or with gearbox.

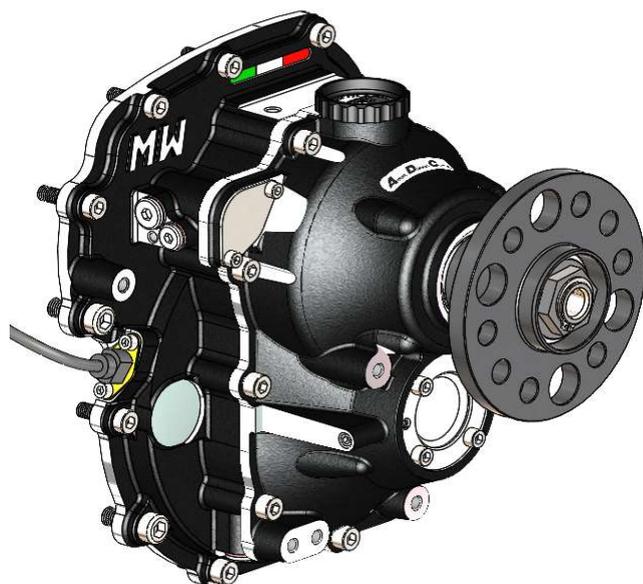
**61-01-00 Description**

In engines with direct transmission to the front of the block, a cover is connected that includes the shaft and the propeller flange: this cover supports the loads deriving from the propeller through two ball bearings of considerable size; the cover is also sized to support the loads deriving from belt drive, often used in rotary wing aircraft. In engines with direct transmission, the propeller revolutions are equal to the engine revolutions and there is no type of flexible coupling between the propeller and the crankshaft. The propeller shaft bearings are lubricated by splashing, using engine oil.



61-01-P

The engines that use the Gearbox instead of this cover mount, the PSRU reducer group, consisting of a pair of helical tooth gears; the propeller shaft is equipped with front cam flexible couplings, to reduce torsional stresses; each shaft is supported by two ball bearings of considerable size. The pair of gears rotates in an oil, and can be easily inspected through the large hole prepared for the introduction of the oil present in the upper part of the casting. The lubrication oil is not the same as that used for the engine: this choice was made to reduce the risk of contamination of the engine oil by metal



61-02-P

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particles produced by the rotation of the gears, and at the same time use a lubricant more suitable for the conditions of high specific pressure that occur in the contact between the gear reducer teeth.

A one-way breather valve is located between the reducer and the motor body.

All gearboxes are equipped with a PG-m (Propeller Governor module): this device constitutes a constant speed propeller control system, with electro-hydraulic control with digital speed setting. On the other hand, it is not possible to use hydraulic governors with centrifugal control keyed on the propeller shaft.

It is also possible to mount electrically controlled variable pitch propellers in flight, with a rotating feed motor in the hub and sliding contacts. This solution is also the only one that can be used on direct drive engines.



In the case of electric pitch drives, before assembly make sure that the control power of the electric actuator is sufficient to overcome the reaction torque of the blades: the latter, characteristic of each type of blade, must be supplied by the manufacturer of the propeller, and calculated at the power of the motor you want to install.



**If the propeller hits the ground or any other obstacle while the engine is running you need to overhaul the gearbox in order to verify the integrity of gears and housings.**



For any reason, loosen or replace the union screws between the body and the cover of the gearbox or between the gearbox or front cover (for direct drive version) and the engine: therefore, avoid using them to fix engine's components or accessories, such as radiator, air intakes or other. Failure to comply with this requirement releases MWfly from any obligation and liability towards the user, and causes the automatic revocation of the guarantee.

## 61-02-00 General Characteristics

All engines have been designs to work with both pushing and tractor applications.

- Maximum gearbox oil temp. in flight conditions (with governor) 110 (130) °C
- Typical gearbox oil temp. in flight conditions (with governor) 90 (105) °C
- Minimum gearbox oil temp. when starting (with recommended oil) -10 °C



Using the engine with gear box oil temperature over the limit indicated will cause an excessive increase of the gap between the gears. This will cause an unusual wearing of the gear.



Starting the engine with gearbox oil temperatures lower than indicated is possible but may be difficult because of the increased viscosity of the oil; in this case it is advisable to use gear oil with a lower viscosity.

<ul style="list-style-type: none"> <li>▪ Reduction ratio</li> </ul>	<ul style="list-style-type: none"> <li>Direct drive 1÷1</li> <li>Type A 1÷1.731</li> <li>Type B 1÷1,958</li> </ul>
<ul style="list-style-type: none"> <li>▪ Max prop speed</li> </ul>	<ul style="list-style-type: none"> <li>Spirit 100 Direct R/L 3500 rpm</li> <li>Spirit 115 Direct R/L 3500 rpm</li> <li>Spirit 122 PSRU R/L 2450 rpm</li> <li>Spirit 135 Direct R/L 4750 rpm</li> <li>Spirit 135 PSRU R/L 2425 rpm</li> <li>Spirit 140 PSRU R/L 2450 rpm</li> <li>Spirit 160 Direct R/L 4750 rpm</li> <li>Spirit 160 PSRU R/L 2425 rpm</li> </ul>
<ul style="list-style-type: none"> <li>▪ Max torque on propeller shaft</li> </ul>	<ul style="list-style-type: none"> <li>Spirit 100 Direct R/L 207 Nm (21,1 Kgm)</li> <li>Spirit 115 Direct R/L 238 Nm (24,3 Kgm)</li> <li>Spirit 122 PSRU R/L 364 Nm (37,1 Kgm)</li> <li>Spirit 135 Direct R/L 210 Nm (22,1 Kgm)</li> <li>Spirit 135 PSRU R/L 411 Nm (41,9 Kgm)</li> <li>Spirit 140 PSRU R/L 450 Nm (45,9 Kgm)</li> <li>Spirit 160 Direct R/L 260 Nm (26,5 Kgm)</li> <li>Spirit 160 PSRU R/L 509 Nm (51,9 Kgm)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Max polar moment of inertia</li> </ul>	<ul style="list-style-type: none"> <li>vers. Direct 5500 Kgcm<sup>2</sup></li> <li>vers. PSRU 7500 Kgcm<sup>2</sup></li> </ul>
<ul style="list-style-type: none"> <li>▪ Min polar moment of inertia</li> </ul>	<ul style="list-style-type: none"> <li>vers. Direct 3000 Kgcm<sup>2</sup></li> <li>vers. PSRU 4700 Kgcm<sup>2</sup></li> </ul>
<ul style="list-style-type: none"> <li>▪ Max static load (propeller weight)</li> </ul>	<ul style="list-style-type: none"> <li>15 Kg</li> </ul>
<ul style="list-style-type: none"> <li>▪ Max static imbalance</li> </ul>	<ul style="list-style-type: none"> <li>10 g</li> </ul>
<ul style="list-style-type: none"> <li>▪ Max dynamic imbalance</li> </ul>	<ul style="list-style-type: none"> <li>0,20 IPS</li> </ul>



The type A gearbox is fitted as standard on the PSRU engines of the Skyline series (Spirit 122 and Spirit 140); the type B gearbox is fitted as standard on the PSRU motors of the Redline series (Spirit 135 and Spirit 160).

#### 61-02-01 Gearbox Oil Capacity

<ul style="list-style-type: none"> <li>▪ Quantity of gear box without governor</li> <li>▪ Quantity of gear box oil with governor*</li> <li>▪ Tolerance on oil level</li> </ul>	<ul style="list-style-type: none"> <li>450 cm<sup>3</sup></li> <li>600 cm<sup>3</sup></li> <li>±50 cm<sup>3</sup></li> </ul>
--	--

\* referred to an installation with MW Hydro pitch propeller without spacer.

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The amount of oil to be introduced into the gearbox can significantly increase depending on the type of hydraulic hub used or in the case of using a propeller spacer: in these cases, it is necessary to establish the amount of oil to be used for refuelling the gearbox, based on the feedback. provided by the level screw.

### 61-02-02 Permissible Loads on the Transmission Shaft

The following table shows the max/radial and max/axial load on the propeller/transmission shaft.

<b>Max load on the shaft [N]</b>	<i>Version Direct</i>	<i>Version PSRU</i>
<i>Max axial continuous load</i>	2000	2000
<i>Max axial load</i>	9000	7000
<i>Max radial continuous load</i>	8000	5000
<i>Max radial</i>	32000	19000

#### 61-01-C

Maximum continuous loads above are calculated for a minimum bearing life of 2200 hours for the standard versions, and for 1000 hours for the version for helicopter (max rpm 4500 without gearbox).

In a standard engine application or fixed-wing aircraft the load on the propeller shaft is normally under the limit indicated in the table, provided you use appropriate and approved propellers and do not perform aerobatic manoeuvres.

In applications on rotary wing aircraft it is necessary to evaluate the loads induced by any pre-rotation or transmission systems (belts), both radially and axially (due for example to misalignment of the pulleys); in these applications it is of absolute importance to quantify and contain the loads due to the torque impulse generated by the large inertia of the main rotor and by the presence of a possible free wheel on the transmission: for this purpose it is advisable to install a slipping clutch or of a flexible coupling.



Failure to comply with these prescriptions can cause serious damage to the transmission system and to the engine structure.

### 61-03-00 Recommended Lubricant

The gearbox has separate lubrication from the engine, with a separate oil pump and lubricant. The oil in the gearbox is used to lubricate the gears and remove heat from them. Since the lubrication of transmission gears is particularly stressful, the lubricating oil used for the gear unit has different characteristics than that used for the engine. The recommended gear box oil should be an oil for a hypoid gear with a thermal degree 80W / 90 API GL5.

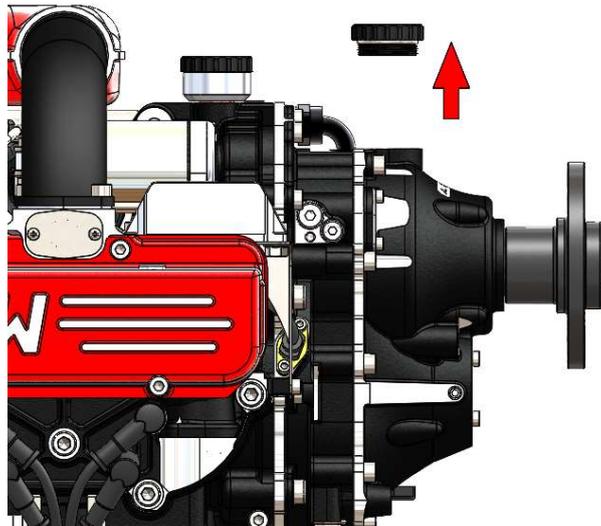
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**A**

After the first 10 hours of operation it is necessary to replace the gearbox oil: if not replaced it will cause damage to the gears or the variable pitch propeller control system, if installed.

### 61-04-00 Refilling Reduction Gear Box

The oil must be refilled by unscrewing the cap positioned above the reducer and the level control cap located on the # 2 bank side of the engine.



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Fill the gear box with the indicated quantity of the recommended oil: the correct oil level is reached when the oil starts to drain from level oil plug on the side of the gearbox.



61-04-P

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Screw the cap back on by hand until it bottoms with the reducer plane; before screwing in again, at the first oil supply, it is advisable to grease the sealing ring on the cap with oil, to prevent the gasket from hardening.  
Through the refuelling hole it is also possible to check the wear of the gearbox gears.



Check the oil level in the gearbox and the condition of the gears at the recommended intervals and in all cases where excessive noise is heard.

### 61-05-00 Verification and Validation

The Fine Tuning of the gear box consists of evaluating the match between the engine and the propeller. For that evaluation follow the instructions below:

- a.** Start the engine, and after the warm up, keep the engine at 1500 RPM: stay away from the propeller and the propeller plane, and observe if the propeller blades stay in the rotation plane and do not bend.
- b.** Repeat the above test with the engine 3000 rpm.
- c.** Perform a flight test an hour before the sunset and flying with the sun at the back and observe the reflection of the sun light on the propeller blades: you should observe there is no vibration of the reflection at any engine speed.

If the above conditions are not met then the propeller is too flexible or there is a dynamic instability that can cause a resonance phenomenon that can be very dangerous. In this case it is better to use a stiffer propeller.



**Check the tightness of the propeller mounting screws using the deadlines provided for in the maintenance schedule or in a shorter time period if prescribed by the propeller manufacturer.**



**After the first flight, check the tightening of the reducer closing screws, as indicated in the maintenance manual: in case of loosening, carefully check the balance and tracking of the propeller; in the case of using variable pitch propellers, also check the blade pitch error.**



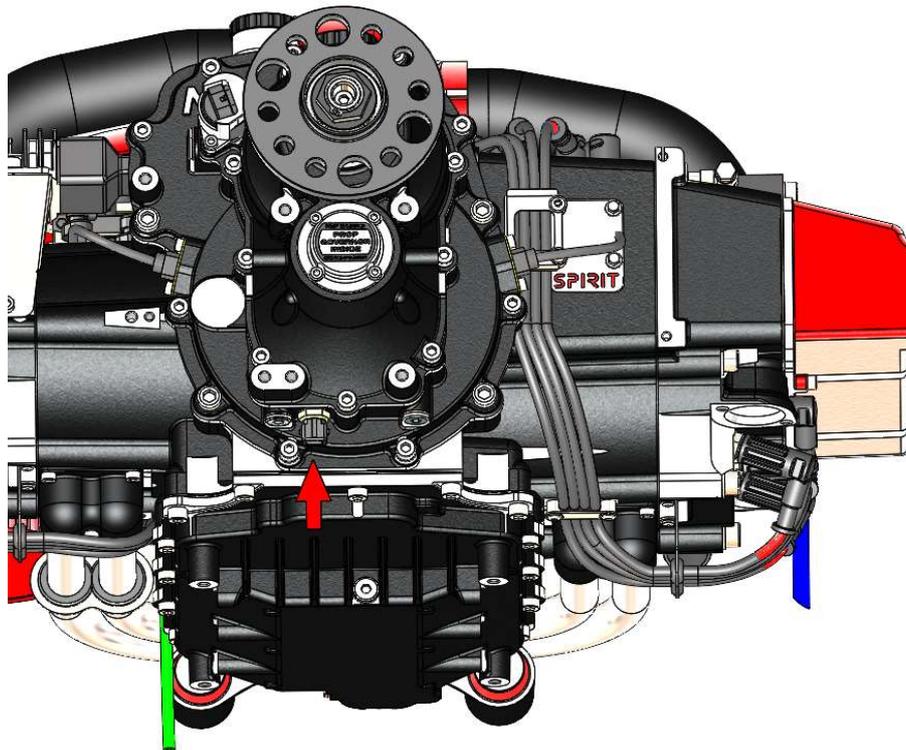
Before flight check the propeller and transmission components by rotating the propeller manually: you should not hear any noise or feel any jamming. Before you do this, make sure that the injection system is not powered.



Do not rotate the propeller in the opposite direction to that of normal rotation of the engine: doing so can damage the tensioning system of the distribution chain and the starter system.

**61-05-01 Gearbox Oil Temperature Measurement**

The measurement of the gearbox oil temperature is done by means of the appropriate sensor, located in the lower part of the reducer: this sensor is supplied with the EM-m or with the HG-m; it can also be requested separately.



61-05-P

Alternatively, the measurement of the gear box oil can be done using a thermotape on the outside of the gear box below the oil level.

To assess the operating temperature of the reducer, it is necessary to perform a flight in significant climatic conditions (ambient temperature above 30 ° C) and check the maximum temperature reached during operation or immediately after the engine is switched off. This temperature must comply with the limits indicated. If the temperature is over the indicated limit, it is necessary to prepare an inlet intake on the cowling in correspondence of the lower part of the gear box.



In addition to cooling problems, a higher than normal gear oil temperature can be associated with problems in the transmission gears or the torsional vibration damping system.



The use of the engine with too high a reducer lubricant temperature causes an increase in noise and wear of the gear teeth. Too low a temperature instead produces a decrease in performance.

**61-10-00 Propeller**

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The propeller is the most important accessory of the entire installation, as it can boost or depress the performance of your engine: to choose the most appropriate propeller carefully read the following notes.

The choice can be made based on a few essential requirements as summarized below.

- Propellers that allow the engine to reach too high an rpm cause the early intervention of the rpm limiter and therefore do not allow a good utilization of the engine, as well as damaging the engine itself.
- Propellers that do not allow the engine to reach, at least 90% of the maximum speed on the ground, cause a loss of performance in the take-off.
- At the same engine rpm, small-diameter and large pitch propellers are better for obtaining high speed performance, but those propellers have poor climbing and acceleration performance.
- Increasing the number of blades increases propeller traction at low speeds, favouring short take-offs and steep climbs, but sacrificing speed performance.
- At the same engine rpm, large diameter propellers and low pitch propellers facilitate climbing performance and acceleration, but reduce speed performance.
- Tapered propellers are better for high speed performance.
- Propellers with a higher pitch are better for high speed performance.
- In flight, variable pitch propellers combine the features of large diameter propellers to those of high pitch value propellers.
- Avoid the installation of propellers with excessively flexible blades, as they cause the occurrence of low-frequency vibrations that are particularly noticeable in reduced percentages of engine power.
- Propellers with wooden hubs require more frequent tightening compared to those equipped with aluminum or composite hubs.



**MWfly declines any responsibility for damages or injuries caused to things or people deriving from the use of unapproved, badly installed or unbalanced propellers. This eventuality causes the immediate cancellation of the guarantee.**



**MWfly does not allow the use of clutch or damper devices or devices other than those provided and original. MWfly prohibits modifying or adding any device that modifies the transmission mechanism.**

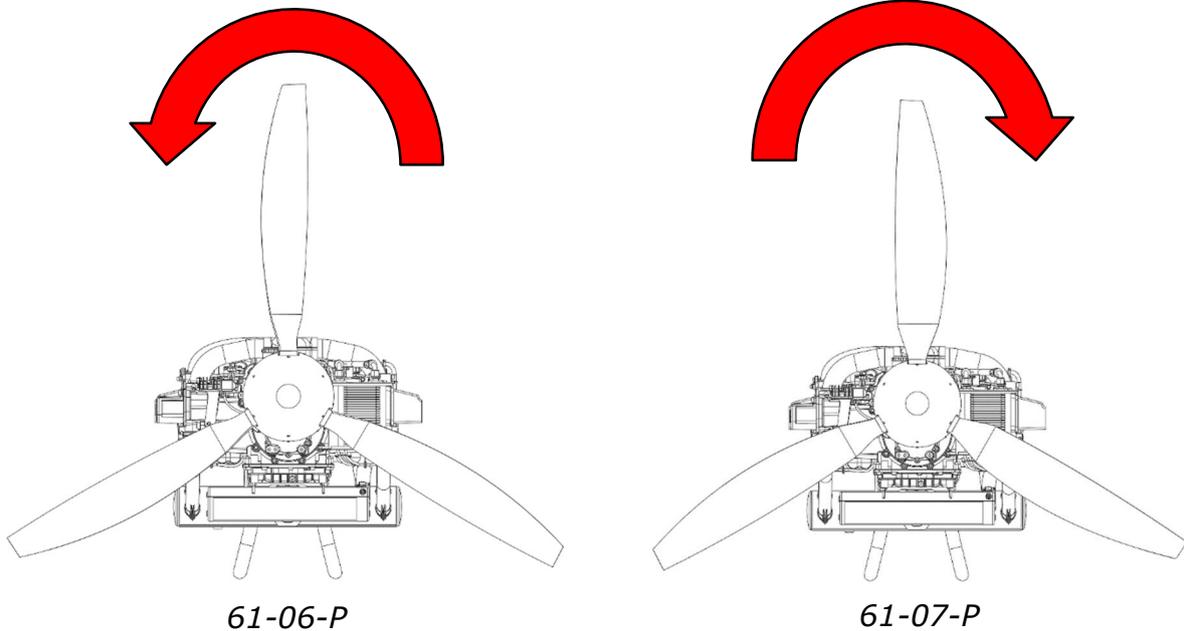
## 61-11-00 Propeller General Features

### 61-11-01 Rotation Direction

The direction of rotation of each version of engine (both with gearbox and direct) is defined with respect to an observer located in front of the propeller, who sees the engine behind it, according to the SAE J824 standard: therefore a propeller that moves in a clockwise direction it rotates to the right (motor "R" right), a propeller that moves in an anticlockwise direction rotates to the left (motor "L" left).

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For greater clarity refer to the following figures.



Counter clockwise rotation = left engine (L)      Clockwise rotation = right engine (R)



Never manually rotate the propeller in the opposite direction. This operation can damage the automatic timing chain tensioners and also disengage the system on the engine starter.



The choice of propeller must comply with the restrictions listed. The use of non-compliant propellers causes the revocation of any form of guarantee on the engine or its parts.



In engines with right rotation, the rotation of the propeller produces a drift to the left of the aircraft, to be contrasted on the ground with the right pedal, and to be adequately balanced in flight with the aerodynamic compensation surfaces. The opposite rule applies to the versions with left rotation.

### 61-11-02 Weight Polar Moment of Inertia

The gear box has been designed to support the load produced by the propeller that a weight not exceeding 15kg and that has a polar moment of inertia admitted must be between 4700 and 7500 Kgcm<sup>2</sup>. In the case of motors without gearbox, the polar moment of inertia must be between 3000 and 5500 Kgcm<sup>2</sup>.

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Theoretically the propeller with a high value of polar moment of inertia increases the regularity of the engine at low RPM and facilitates the engine start up.



**For any reason, use propellers with mass or polar moment of inertia that do not comply with the requirements: this eventuality causes the immediate revocation of the guarantee and frees MWfly from any further obligation towards the user.**



The use of propellers with inadequate structural rigidity can cause dangerous vibrations in the transmission system, with consequent damage to the gearbox.

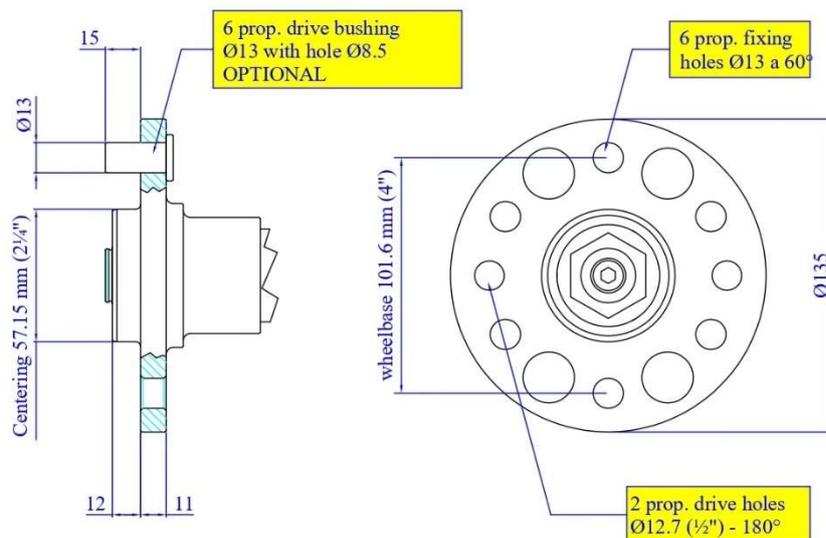
## 61-12-00 Installation

### 61-12-01 Engine Flange

The propeller flange is keyed to the gearbox output shaft through a forced coupling and a large nut. It is made of high-strength steel, and is passivated against corrosion: this protection is sufficient to avoid oxidation in most uses. However, if the engine is used in highly salty environments (coastal locations) or heavily polluted, it should be greased periodically with anti-corrosion oil. Also avoid carving or abrading the surface of the propeller flange to preserve the integrity of the surface treatment.



**The propeller flange must not be removed for any reason: failure to comply with this requirement is a potential source of danger and frees MWfly from any obligation or liability towards the user.**



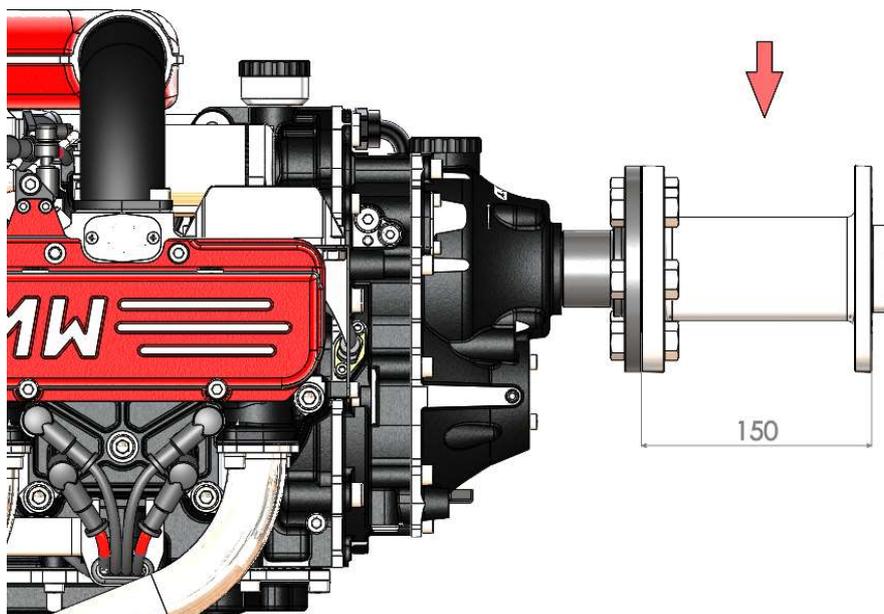
61-08-P

- Type ARP 502
- External diameter 135 mm
- Boss diameter for propeller 2 ¼" (57.15 mm)
- Propeller fixing hole 6 holes D13 on D4" (101.6 mm)
- Propeller drive 2 holes ½" (12.7 mm) on D4" (101.6 mm)
- Max overhang from flange 150 mm

The propeller is tightened by means of 6 ½" screws inserted in the 6 holes D13; however, it is possible to insert 6 D13mm bushing in the same holes and use 6 M8 screws to fix the propeller; in this case the dragging is ensured by the bushes, and therefore the half-inch dragging pins must not be used.

### 61-12-02 Extension

It is possible to use a 150 mm maximum extension on the propeller shaft. The extension should be perfectly coaxial and concentric with the propeller shaft to avoid any imbalance load on the propeller shaft.



61-09-P



Longer extensions than the maximum allowed can cause an overload on the ball bearings of the gear box, with the risk of stopping the ball bearing.



The rearmost point of the blade profile must be considered as the plane of rotation. The height of 150mm is therefore to be understood as inclusive of any overhang already contained in the propeller hub.

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In case of using a propeller spacer in combination with a hydraulically operated propeller, it is advisable to make the spacer itself with a central hole for the passage of small diameter oil, to reduce the amount of oil needed to drive the propeller.

### 61-12-03 Implementation

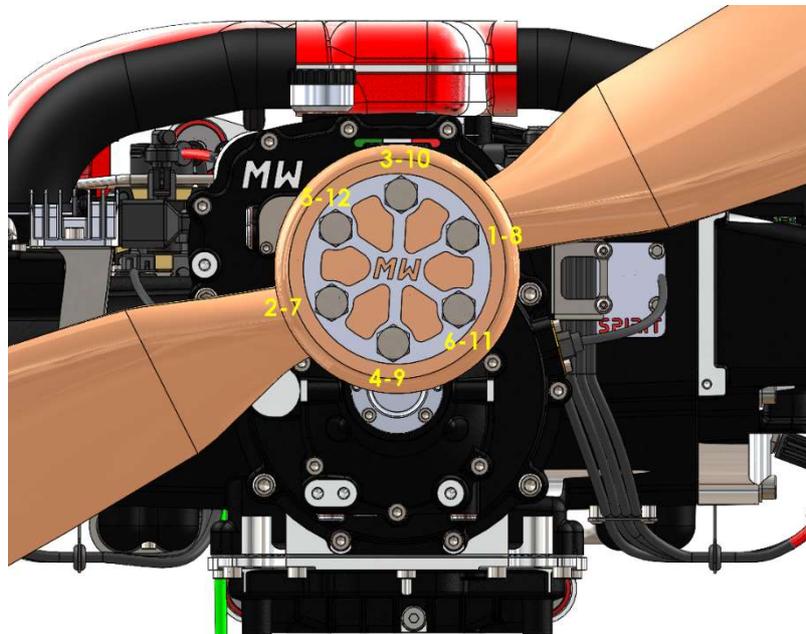


If a fixed pitch propeller made of wood is used, we recommend a mounting hole type ARP 502, which ensures greater stability and safety.

### Necessary Materials

(The steps for mounting a propeller with M8 locking screws and D13 drive sleeves are shown in brackets).

1. Torque wrench
  2. Open end key 19 mm (Allen key 6 mm)
  3. Open end key 19 mm (Open end key 13 mm)
  4. Threadlocker medium
- a.** Carefully clean the propeller surface and the flange surface that will face each other and remove any debris caused by the previous assembly.
  - b.** Insert the two half-inch drive pins into the two pre-drilled holes. (insert the 6 dragging bushes into the 6 holes D13.)
  - c.** Fit the propeller on the flange and on the centring hub, so that the drive bushes fit effortlessly into the seats made on the propeller.
  - d.** If a wooden propeller is mounted, it is necessary to overlap with the hub an anti-sinking dish, which avoids the wood to dent following the tightening imposed on the screws.
  - e.** Depending on the propeller type
    - Hub with passing holes (generally a fixed step propellers): insert the six tightening screws through the propeller holes, screw [4] on each the nut and shim and tighten [3; 1+2] at 35 Nm (22 Nm), or minor, if otherwise prescribed by the propeller manufacturer or in the case of use of wooden propellers; The tightening must take place with cross order, following the scheme shown in the figure.
    - Hubs with generally propelled propellers with variable pace: insert the six tightening screws from the back of the propeller flange and then screw them [3; 4] in the 6 holes of the propeller; Tighten [1+3] at 35 Nm (22 Nm), or minor, if otherwise prescribed by the propeller manufacturer; The tightening must take place with cross order, following the scheme shown in the figure.



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- f.** After tightening, check the tracking of the blades: the maximum deviation must comply with what is reported.

### 61-12-04 Balance and Tracking

To minimize vibration and mechanical stress on the transmission components it is essential to install the propeller perfectly balanced both statically and dynamically. For the same purpose it is necessary to check the tracking of the blades, the maximum deviation between the rotation plane of the blades, measured at the vertex of each blade; in the case of propellers with more than 2 blades, it is calculated as the difference between the rearmost blade and the most advanced blade. A final check, in the case of variable pitch propellers, concerns the maximum keying error between the blade with the highest incidence and the one with the lowest incidence.

- |  |               |
|--|---------------|
| ▪ Maximum static imbalance             | 3 g           |
| ▪ Maximum dynamic safety unbalance     | 0,15 IPS      |
| ▪ Maximum dynamic unbalance of comfort | 0,07 IPS      |
| ▪ Maximum tracking error               | ± 1,6 mm      |
| ▪ Maximum pitch error of blade keying  | ± 0,8 degrees |



**Propeller balancing and tracking are very important for the safety and durability of the transmission system; MWfly declines all responsibility for breakages or damage caused by inadequate and improper assembly of propellers.**



In the event of an accidental impact with the ground, it is necessary to check and rebalance the propeller before resuming flight.

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The use of dynamically balanced propellers reduces vibrations due to rotation and significantly increases flight comfort.

### 61-30-00 Constant Speed Electro-Hydraulic Governor HG-m

On each engine equipped with a gearbox it is possible to add a constant speed propeller governor, with open circuit electro-hydraulic control: this device is composed of a trochoidal pump that moves the gearbox lubrication oil, a control valve, a valve pressure relief and a step-by-step electric actuator.

The governor allows, with a minimum weight increase and a minimum complexity, to have a completely automatic, fast and safe propeller pitch variation system, which increases performance both in take-off and in level flight. The governor can also be mounted at a later time, with a very little invasive intervention on the engine.

The setting of the desired revs for the flight is done through the EM-m instrument panel or, in the case of cockpit with analogue instrumentation, through the PG-m instrument: these instruments are connected to the engine electrical system via the CAN line. For a description of the functions and how to install these tools, refer to VPP manuals.

#### 60-30-01 Characteristics of the Components

▪ Pump flow rate	8 l/min @ 4000 rpm
▪ Operating pressure	10 bar
▪ Type of electric valve control	Step by step
▪ Number of steps	1696
▪ Error un RPM target	±20 rpm

#### 61-30-02 Installation

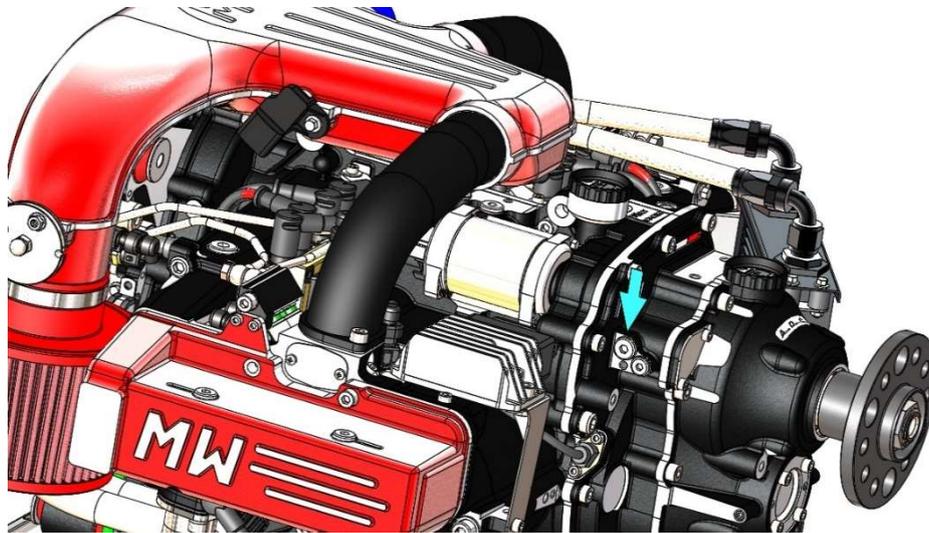
For the installation of the governor, refer to the DMA.A01 manual.

### 61-31-00 Closed-circuit Hydraulic Pitch Variation System

#### 61-31-01 Description

In addition to the electrohydraulic open circuit governor HG-m, it is possible to use a closed-circuit hydraulic propeller pitch variation system: this type of system obtains the pitch variation of the propeller by varying the amount of oil present inside the hub. propeller by rotating a manual pump installed in the cabin. The most advanced systems provide an electric pump instead of the manual pump, which can be installed in the cabin or in the engine compartment.

The assembly of these systems is possible only on engine equipped with gearbox and takes place following the manufacturer's instructions: on the right side of the gearbox there is the predisposition for the assembly of the hydraulic fitting for the connection of the control pump.



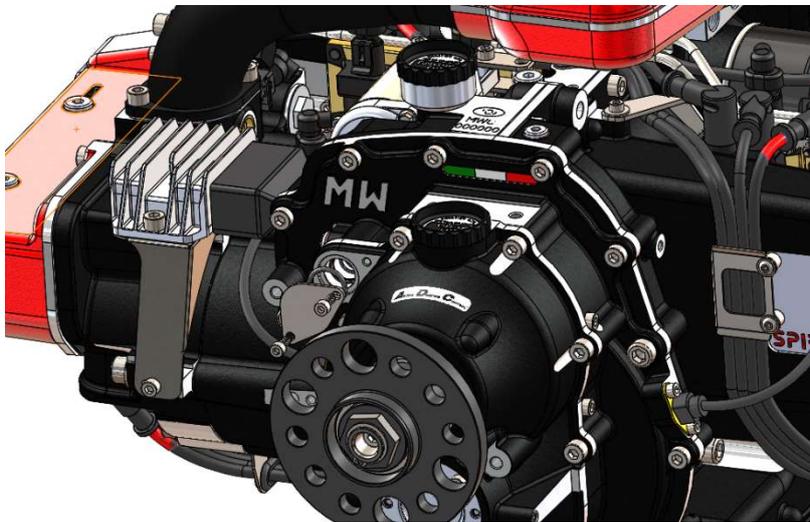
61-11-P

### 61-31-02 Installation

For the correct assembly of the fitting of these propellers it is necessary to use the appropriate kit, following the instructions below.

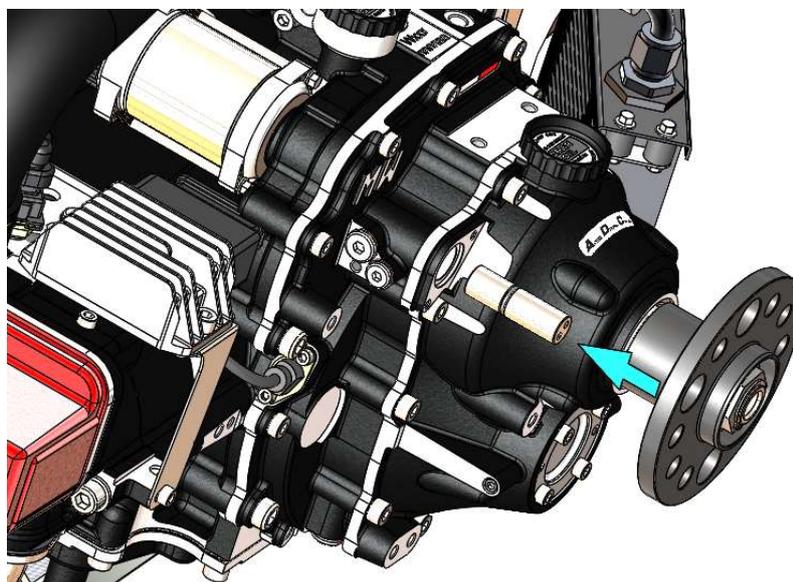
#### Necessary Materials

1. Torque wrench
  2. Allen key 6 mm
  3. Allen key 4 mm
  4. Vaselina tecnica
  5. Other tools depending on the materials chosen during installation
- a.** Remove [2] the threaded plug shown in the figure.
  - b.** Unscrew [2] and remove the cylindrical head screw in the centre of the propeller flange: for removal it may be necessary to use the gearbox locking tool to be screwed in place of the gearbox oil filler cap.
- A** This screw blocks the flow of oil inside the propeller hub: therefore, failure to remove it does not allow the pitch variation system to work.
- c.** Remove the actuator cover, unscrewing [3] the two screws: be careful to also remove the O-ring located under the cover.



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- d.** Mount the O-ring on the conversion kit insert.
- e.** Introduce the insert into the hole of the actuator cover, after having applied Vaseline [4] on the seal to facilitate its insertion. Pay attention to the mounting direction: the threaded holes must remain visible.



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- f.** Reassemble the actuator cover and the sealing O-ring, tightening [1 + 3] the two screws to a torque of 4 Nm.
- g.** Instead of the threaded plug, mount [5] a hydraulic connection for high pressure pipes with a suitable thread. This fitting is not part of the conversion kit, as the type of fitting depends on the type of propeller used.

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- h.** Assemble [5] the propeller hub and the blades according to the procedures provided by the manufacturer of the variable pitch hub.
- i.** Bleed the system according to the methods described by the manufacturer of the variable pitch system.



**Before flying with a variable pitch system, electric or hydraulic, it is necessary to check its perfect functioning on the ground.**

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## 72-00-00 ENGINE

For simplicity and clarity, only the information relevant to installation is reported in this manual. If necessary, complete the information with the operation or routine maintenance manual.

### 72-01-00 Description

#### 72-01-01 *Intended Use*

The **SPIRIT** engines have been designed to equip ULM, Experimental or LSA category aircraft with two or three axes, with the required power in accordance with the power delivered by the engine.

The use of these engines is therefore intended for recreational purposes only, in installations where a sudden stop of the engine does not affect safety.



**In order to use the engine safely, in addition to the operating limits, it is also necessary to comply with the maintenance deadlines indicated in the scheduled maintenance program.**



In no way can the guarantee and safety specifications be extended to uses other than those mentioned above. MWfly declines all responsibility for damage or injury caused to people or things resulting from failure or sudden stop of the engine.

Improper use of the engine causes the immediate revocation of the warranty and frees MWfly from any further obligation towards the user.



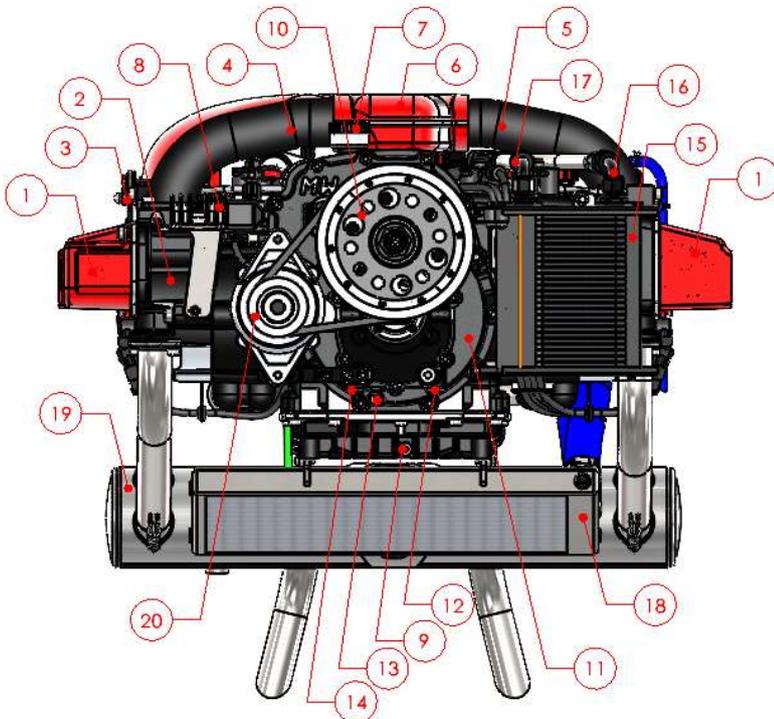
The engine can be used within and not beyond the time limits imposed by the TBO: after this period, it is necessary to have the engine completely overhauled at an authorized service centre before using it again.



To safeguard the integrity of the engine it is necessary to install and use it properly. It is therefore important to verify, through the instrumentation, that the reported operating limits are respected in all operating conditions.

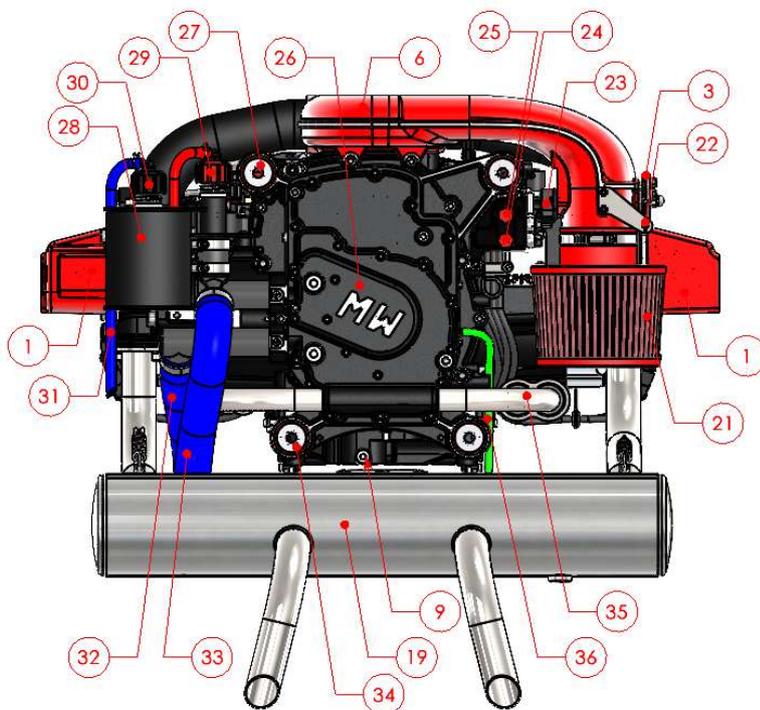
#### 72-01-02 *Location and Component Identification*

Parts and engine components are named and located as shown in the following figures. The letter (o) identifies an optional component; the letter (v) identifies components present only in some versions; the letters A and B respectively identify the main circuit and the auxiliary circuit of injection / ignition.



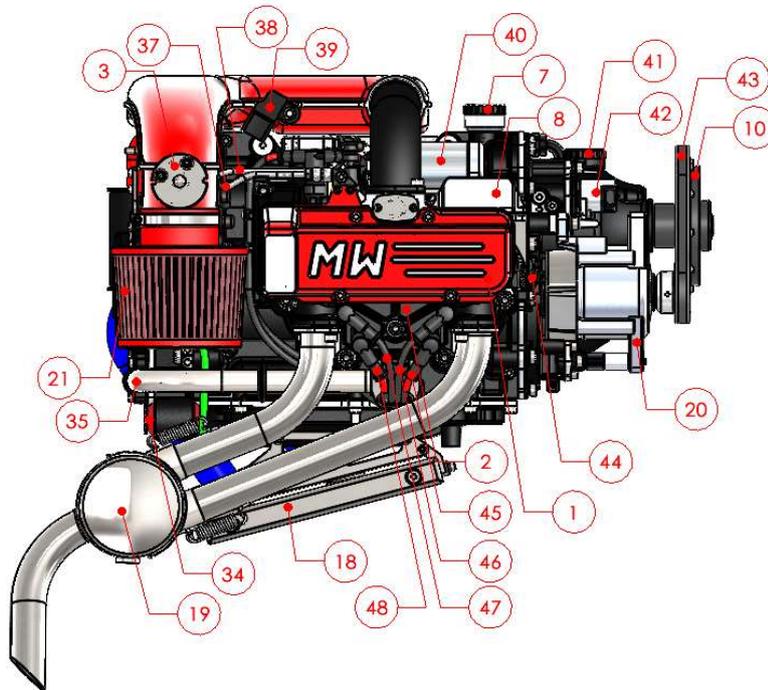
72-01-P

1. Head cover
2. Head
3. Throttle cam
4. Air intake manifold #1
5. Air intake manifold #2
6. Airbox
7. Engine oil filler cup
8. Voltage regulator
9. Oil plug output
10. Propeller Flange
11. Gearbox (v)
12. Gearbox oil plug output (v)
13. Gearbox oil temperature sensor (o)
14. Safety valve VPP (o)
15. Engine oil radiator (o)
16. Inlet oil radiator hose (o)
17. Outlet oil radiator hose (o)
18. Water radiator (o)
19. Exhaust system (o)
20. Auxiliary generator (o)



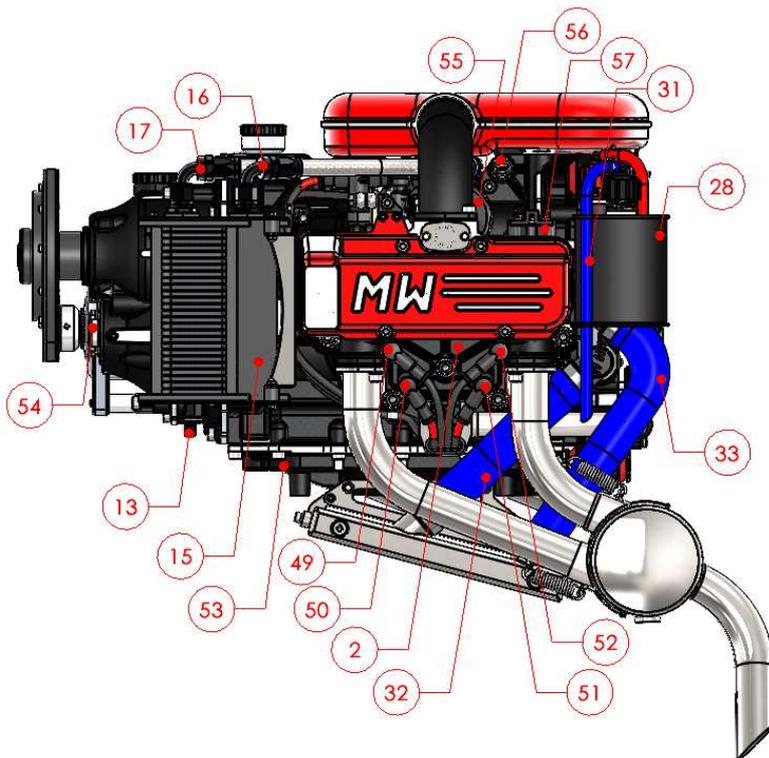
72-02-P

21. Air filter
22. Throttle cable locking
23. Throttle position sensor
24. Fuel inlet line port
25. Fuel outlet line port
26. Water pump
27. Upper attachment points for wall mounting (2x)
28. Expansion water tank
29. Pressurized cup for water circuit
30. Expansion tank cup
- 31.
32. Expansion tank vent
33. Inlet water radiator hose (o)
34. Outlet water radiator hose (o)
35. Lower attachment points for wall mounting (2x)
36. Water circuit line
37. Water pump vent



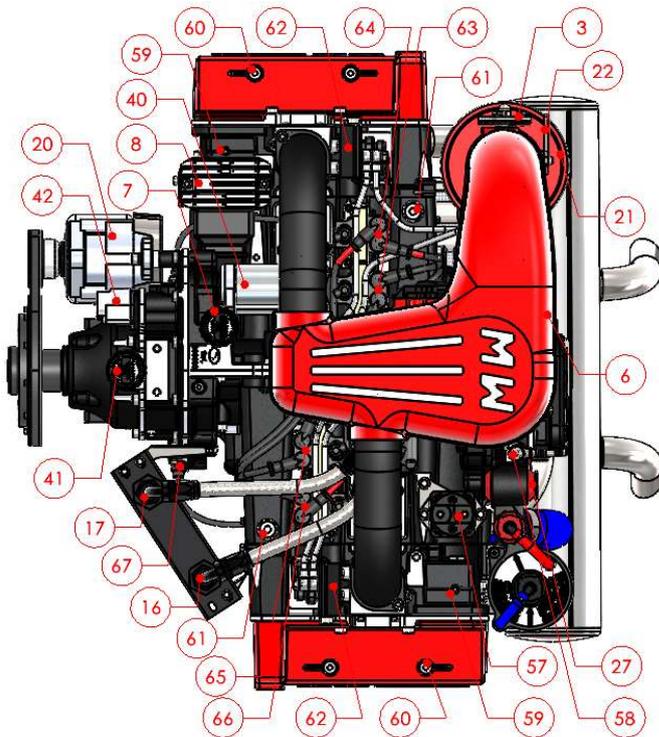
72-03-P

- 38. Fuel delivery pipe
- 39. Fuel return pipe
- 40. Air intake pressure and temperature sensor
- 41. Starter
- 42. Reduction oil filler cap
- 43. Stepper motor for VPP (o)
- 44. Auxiliary generator belt (o)
- 45. Rpm sensor circuit B
- 46. Spark plug cable cyl.1 circuit B
- 47. Spark plug cable cyl.1 circuit A
- 48. Spark plug cable cyl.2 circuit a
- 49. Spark plug cable cyl.2 circuit B



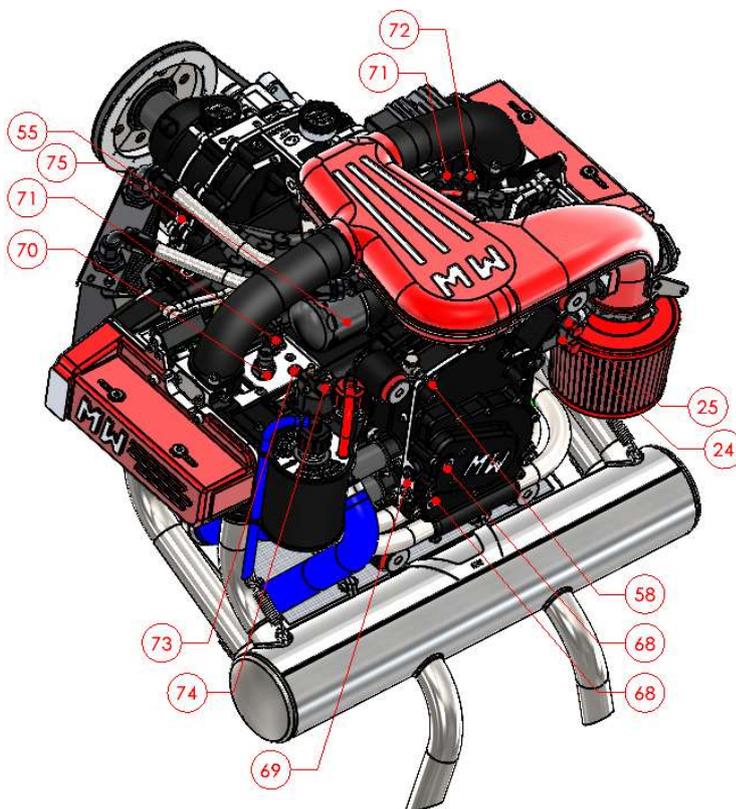
72-04-P

- 50. Spark plug cable cyl.3 circuit A
- 51. Spark plug cable cyl.3 circuit B
- 52. Spark plug cable cyl.4 circuit B
- 53. Spark plug cable cyl.4 circuit A
- 54. Oil sump
- 55. Pump for VPP (o)
- 56. Engine oil filter
- 57. Engine oil pressure switch (v)
- 58. Start relay



72-05-P

- Crankcase vent
- 59. Water circuit vent
- 60. Timing inspection cap
- 61. Aerobatic oil circuit predisposition
- 62. Fuel injector group
- 63. Ignicion coil cyl.1 e cyl.3 circuit A
- 64. Ignicion coil cyl.1 e cyl.3 circuit B
- 65. Ignicion coil cyl.2 e cyl.4 circuit A
- 66. Ignicion coil cyl.2 e cyl.4 circuit B
- 67. Rpm sensor cicuit A



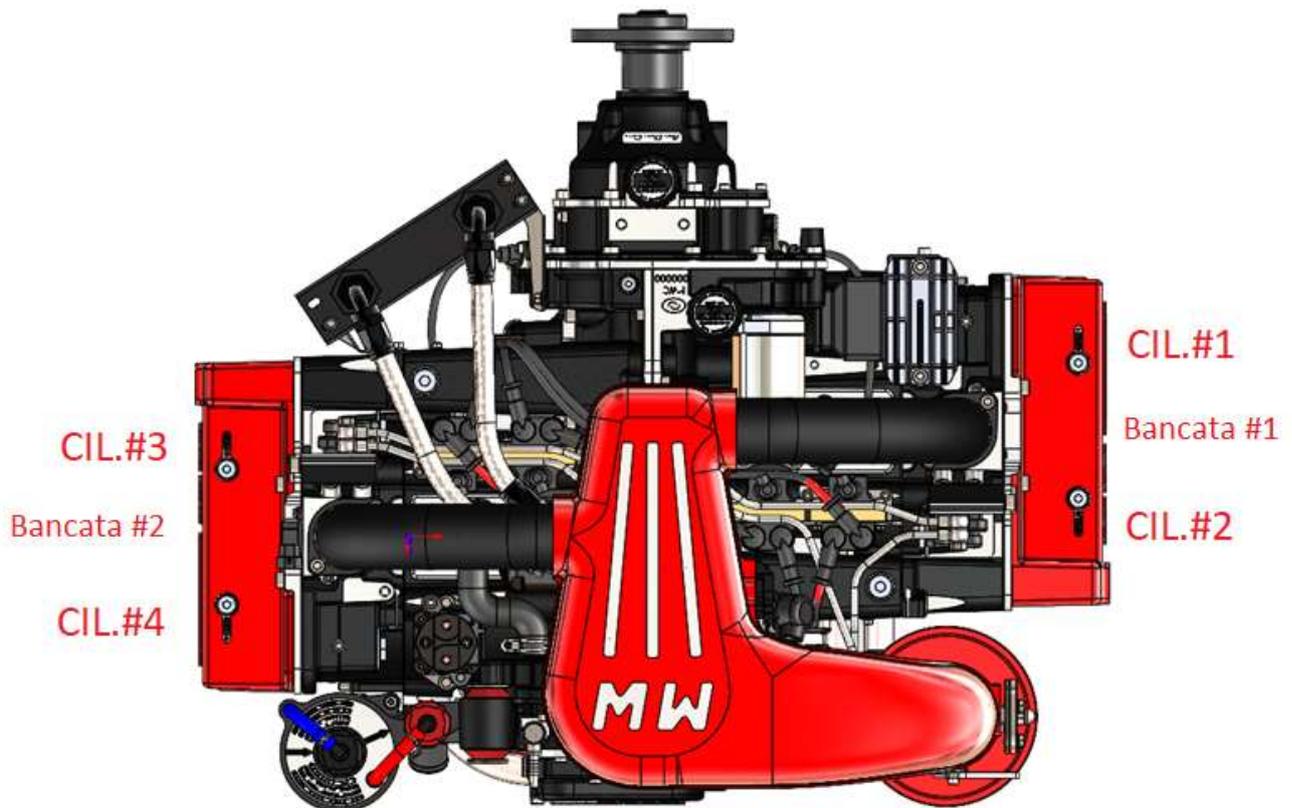
72-06-P

- 68. Rear cabin heater predisposition
- 69. Side cabin heater predisposition
- 70. Engine oil pressure sensor (o)
- 71. Water temperature sensor
- 72. Oil temperature sensor
- 73. M10x1 predisposition for liquid temperature sensor (1 on each bank)
- 74. Terminal for starter cable
- 75. Gearbox oil check level cup

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### 72-01-03 Designation of the Cylinders

The designation of the cylinders is that shown in the following figure, and is the same for both engines with right rotation and for engines with left rotation. Looking at the engine from above with the propeller flange up, cylinder # 1 is the first on the top right, cylinder # 2 the second on the right, cylinder # 3 the first on the left and cylinder # 4 the second on the left; bank # 1 (cylinders # 1 and # 2) is the one on the right and bank # 2 (cylinders # 3 and # 4) the one on the left.



72-07-P

The ignition order for direct counterclockwise or geared hourly engines is 1-2-3-4; the ignition order for direct or counterclockwise geared hourly engines is 4-3-2-1.



**The user assumes all risks deriving from the use of non-original accessories, as they can compromise flight safety or alter the characteristics of the engine.**

### 72-01-04 Original Accessories



Before deciding the position of the engine on the aircraft, it is necessary to establish which accessories you want to use, to be able to predict their size and weight in the installation phase.

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The following table shows a list of the main accessories with their description: the use of these accessories considerably simplifies installation and increases safety. The installation and maintenance required for some of these accessories is integrated in the engine manuals.

<i>Acronym</i>	<i>Meaning</i>	<i>Description</i>
AG-m	Auxiliary generator module	External auxiliary generator
BM-m	Bed Mounting module	Adapter for bed mounting
CC-m	Can to can module	CAN interface that receive the data from the CAN line of the ECUs and send the data on a second CAN line with aerospace protocol used by standard aviation instrumentation
CR-m STD	Cooling radiator module standard	Standard engine liquid cooling radiator
CR-m STOL	Cooling radiator module standard	STOL aircraft engine liquid cooling radiator
EM-m	Engine monitor module	8" Display for engine and flight data
EX-m	Exhaust module	4 in 1 exhaust system
FD-m	Fuel delivery module	Fuel pumps and filter groups (2+2)
OC-m	Oil cooler module	Engine oil cooler
HC-m	Hydraulic controller module	Hydraulic variable pitch propeller system
PG-m	Propeller monitor module	Hydraulic constant speed propeller control display

72-01-C

## 72-02-00 General Characteristics

- 4 stroke Otto cycle
- 4 cylinder boxer
- SOHC (Single Over Head Camshaft) distribution, gear and chain driven, taper with synthesized register shim, 2 valves per cylinder
- Water cooling system with water pump and double involute, water tank expansion integrated thermostat, stainless steel pipe line
- Forced lubrication system with gerotor pump, semi dry oil sump, all lubricant system ducts integrated inside the engine.
- Electronic ignition with inductive coil, fully f(RPM, TPS) mapped with correction with engine and air temperature, and altimetric correction
- Electronic fuel injection, fully f(RPM,TPS) mapped, with correction with engine temperature and altimetric correction
- CAN aerospace protocol data transmission

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- Fuel system with electric fuel pump, the main fuel pump is controlled automatically by the ECU, the auxiliary fuel pump is provided with the FD-m, fuel pressure regulator and steel pipes are integrated on the engine
- Integrated gearbox with separate splash lubrication, helical tooth gears, predisposition for hydraulic propeller pitch control (not present in the versions without reducer)
- Front cam dissipative torsional damping system with return springs
- ADC (Active Damping Control) anti-kickback system in starting and stopping
- Electric start system, with start relay integrated on the engine and with, oil-centrifugal decompressor and safety clutch
- Charging system with permanent magnet generator, oil cooled and external current regulator

### 72-02-01 Version Available

Each motor model is available with right or left rotation.

The direction of rotation of each version of engine (both with gearbox and direct) is defined with respect to an observer located in front of the propeller, who sees the motor behind it, according to the SAE J824 standard: therefore a propeller that moves in a clockwise direction it rotates to the right (engine "R" right), a propeller that moves in an anticlockwise direction rotates to the left (engine "L" left).

Each engine model can use either pulling propellers or pushing propellers.

The following table summarizes the main features of the **SPIRIT** engines series

Name	Product code	Max power [CV]	Max continuous power [CV]	Max engine rpm [rpm]	Max prop axel rpm [rpm]
<i>Spirit 100 Direct L</i>	W011	100	100	3500	3500
<i>Spirit 100 Direct R</i>	W012	100	100	3500	3500
<i>Spirit 115 Direct L</i>	W013	115	115	3500	3500
<i>Spirit 115 Direct R</i>	W014	115	115	3500	3500
<i>Spirit 135 Direct L</i>	W017	135	120	4750	4750
<i>Spirit 135 Direct R</i>	W018	135	120	4750	4750
<i>Spirit 160 Direct L</i>	W023	160	142	4750	4750
<i>Spirit 160 Direct R</i>	W024	160	142	4750	4750
<i>Spirit 122 PSRU L</i>	W015	122	110	4250	2450
<i>Spirit 122 PSRU R</i>	W016	122	110	4250	2450
<i>Spirit 135 PSRU L</i>	W019	135	115	4750	225
<i>Spirit 135 PSRU R</i>	W020	135	115	4750	2425
<i>Spirit 140 PSRU L</i>	W021	140	125	4250	2450
<i>Spirit 140 PSRU R</i>	W022	140	125	4250	2450
<i>Spirit 160 PSRU L</i>	W025	160	137	4750	2425
<i>Spirit 160 PSRU R</i>	W026	160	137	4750	2425

72-02-C



# Installation Manual for SPIRIT engines

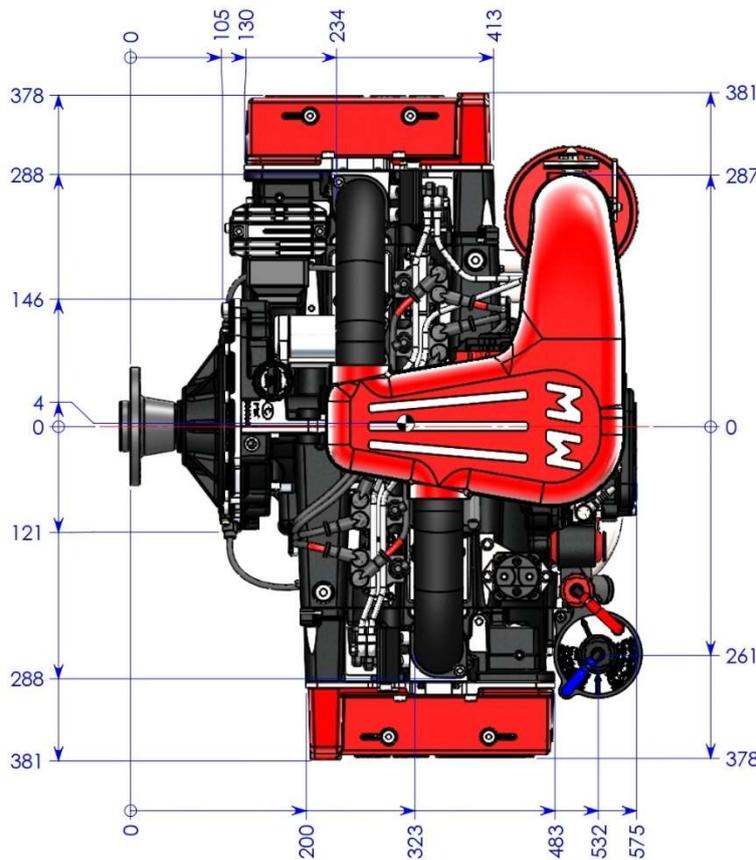
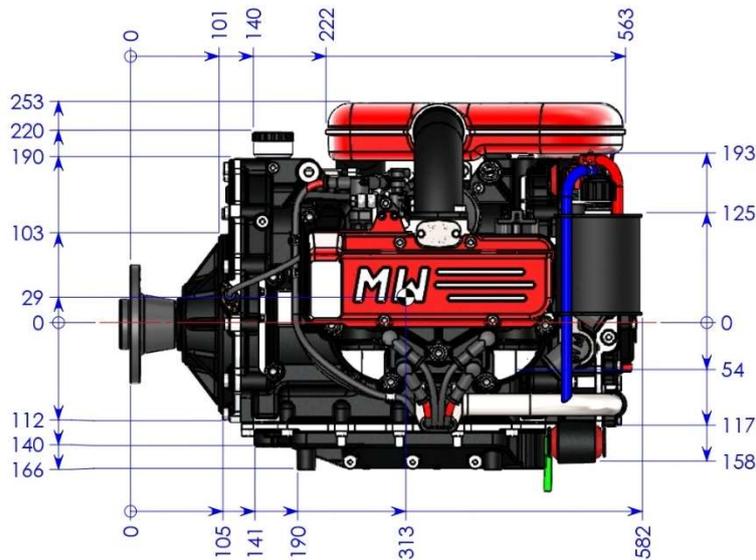
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## 72-02-02 Dimensions

### DIMENSION DIRECT VERSION



72-08-P



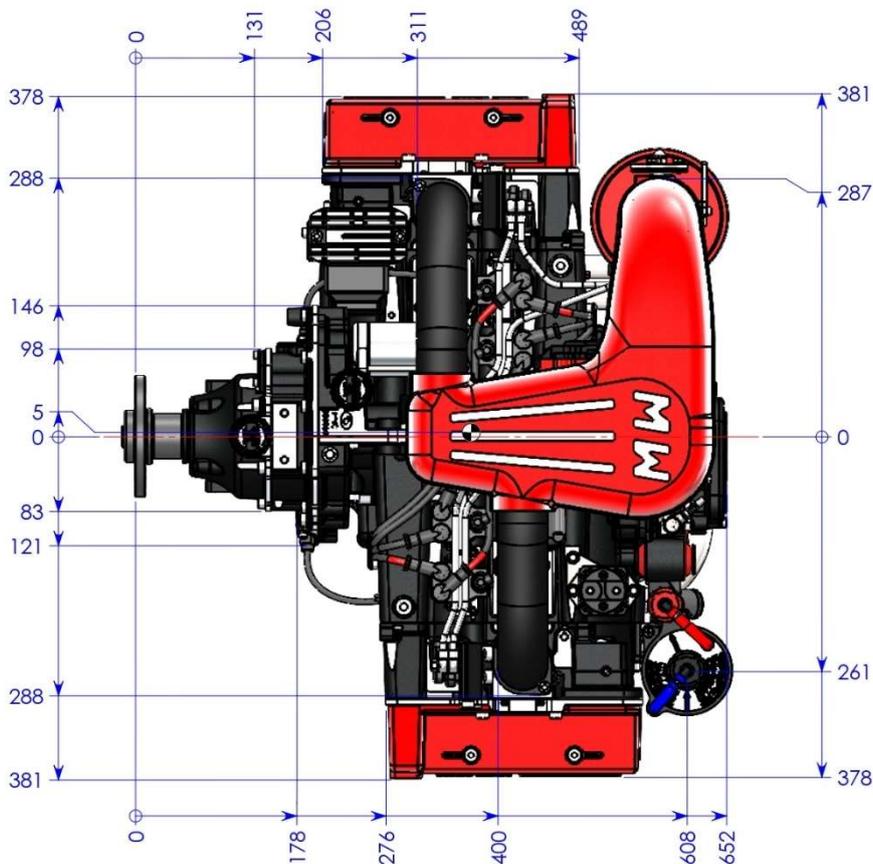
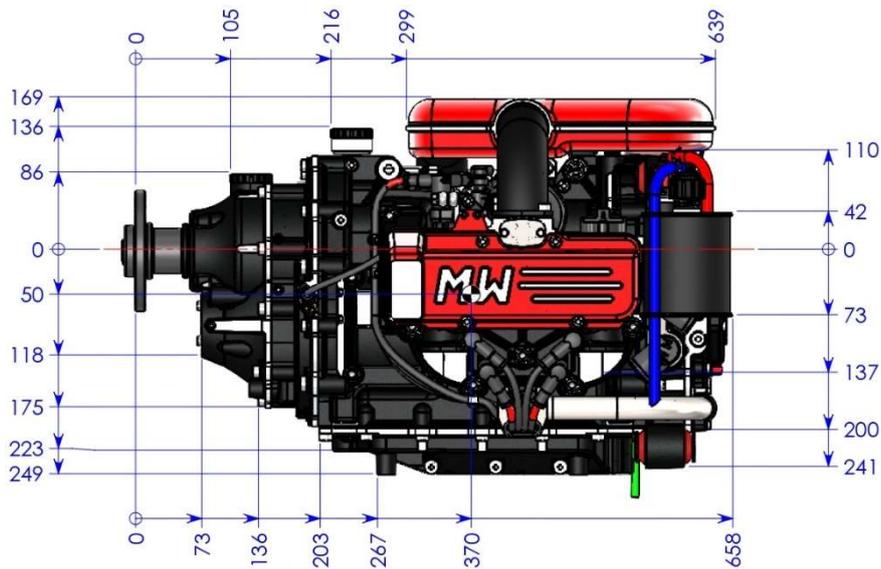
# Installation Manual for SPIRIT engines

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## DIMENSION VERSION with PSRU



72-09-P



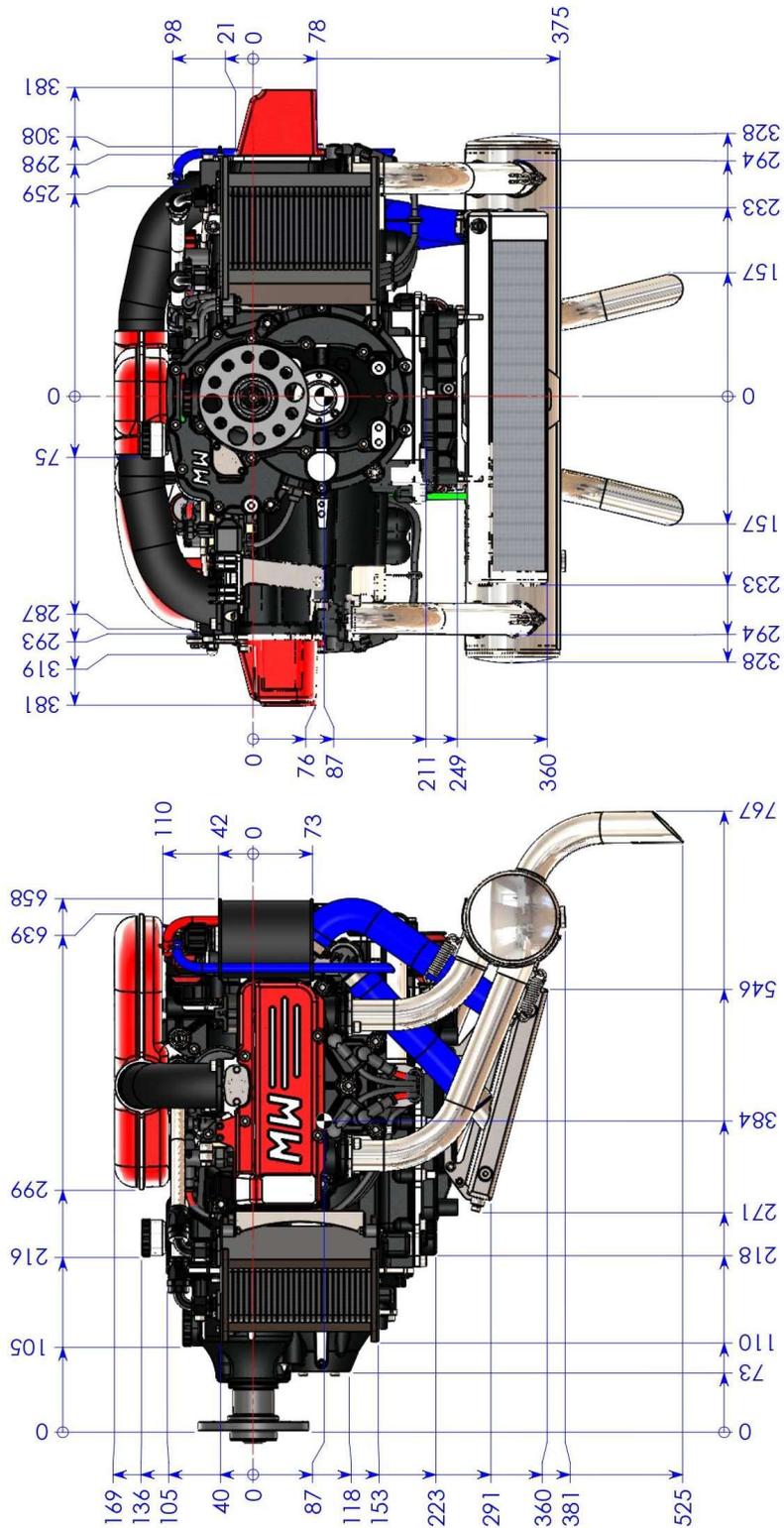
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## DIMENSION VERSION with PSRU + CR-m + OC-m + EX-m



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<b>Direct Version</b>			
<b>Max dimension [mm]</b>	<i>direction -</i>	<i>direction +</i>	<i>total</i>
<i>Maximum along the x axis</i>	12	578	590
<i>Maximum along the y axis</i>	381	381	762
<i>Maximum along the y axis</i>	166,3	252,5	418,8

72-03-C

<b>Version with PSRU</b>			
<b>Max dimension [mm]</b>	<i>direction -</i>	<i>direction +</i>	<i>total</i>
<i>Maximum along the x axis</i>	15	658	673
<i>Maximum along the y axis</i>	381	381	762
<i>Maximum along the y axis</i>	249	169	418

72-04-C

<b>Direct Version with Radiator and Standard Exhaust</b>			
<b>Max dimension [mm]</b>	<i>direction -</i>	<i>direction +</i>	<i>total</i>
<i>Maximum along the x axis</i>	12	688,6	700,6
<i>Maximum along the y axis</i>	381	381	762
<i>Maximum along the y axis</i>	441,8	252,5	694,3

72-05-C

<b>Version with PSRU and with Radiator and Standard Exhaust</b>			
<b>Max dimension [mm]</b>	<i>direction -</i>	<i>direction +</i>	<i>total</i>
<i>Maximum along the x axis</i>	15	764,6	779,6
<i>Maximum along the y axis</i>	381	381	762
<i>Maximum along the y axis</i>	525	169,3	694,3

72-06-C

The tolerance on these dimensions is  $\pm 5$  millimetres.

### 72-02-03 Weights

The following table shows the dry weight of the engine and the weight with lubricants. The weight includes all the accessories needed to fly (internal generator, voltage regulator, starter relay, thermostat, water expansion tank, wiring loom, rubber mounting, air filter)

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<b>Weight [Kg]</b>	<i>Dry</i>	<i>With oils</i>
<i>Spirit 100 Direct R/L</i>	81	84,5
<i>Spirit 115 Direct R/L</i>	81	84,5
<i>Spirit 135 Direct R/L</i>	81	84,5
<i>Spirit 160 Direct R/L</i>	81	84,5
<i>Spirit 122 PSRU R/L</i>	86,5	90,5
<i>Spirit 135 PSRU R/L</i>	86,5	90,5
<i>Spirit 140 PSRU R/L</i>	86,5	90,5
<i>Spirit 160 PSRU R/L</i>	86,5	90,5

72-07-C

### Accessories

- |   |        |
|---|--------|
| ▪ Injection and ignition control unit group       | 2600 g |
| ▪ AG-m: External Auxiliary Generator              | 4100 g |
| ▪ BM-m: Lower Motor Connections (4 pieces)        | 730 g  |
| ▪ CR-m STD: Standard Radiator                     | 2100 g |
| ▪ CR-m STOL: STOL Aircraft Radiator               | 3400g  |
| ▪ EM-m: Display 8"                                | 1230g  |
| ▪ EX-m: Exhaust System                            | 5850 g |
| ▪ FD-m: Fuel Pumps and Filter Groups              | 2750 g |
| ▪ OC-m: Engine Oil Cooler                         | 1450 g |
| ▪ HC-m: Variable Pitch Propeller Hydraulic System | 460 g  |
| ▪ PG-m  | 150 g  |

### Power/Weight Ratio

The following table shows the power-to-weight ratio values of each engine version, in the dry condition and with lubricants.

<b>Power/weight ratio [CV/Kg]</b>	<i>Dry motor</i>	<i>Motor with lubricant</i>
<i>Spirit 100 Direct R/L</i>	1,23	1,18
<i>Spirit 115 Direct R/L</i>	1,42	1,36
<i>Spirit 135 Direct R/L</i>	1,67	1,60
<i>Spirit 160 Direct R/L</i>	1,97	1,89
<i>Spirit 122 PSRU R/L</i>	1,41	1,35
<i>Spirit 135 PSRU R/L</i>	1,56	1,49
<i>Spirit 140 PSRU R/L</i>	1,62	1,55
<i>Spirit 160 PSRU R/L</i>	1,85	1,77

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**72-02-04 Position of Centre of Gravity CoG**

<b>Direct Version</b>		
<b>Position of centre of gravity CoG [mm]</b>	<i>Engine only</i>	<i>Engine with standard exhaust system and radiators</i>
<i>X axis</i>	313	323
<i>Y axis</i>	4	0
<i>Z axis</i>	29	-9

72-09-C

<b>Version with PSRU</b>		
<b>Position of centre of gravity CoG [mm]</b>	<i>Engine only</i>	<i>Engine with standard exhaust system and radiators</i>
<i>X axis</i>	370	384
<i>Y axis</i>	5	0
<i>Z axis</i>	-50	-87

72-10-C

The values shown, referring to the "Engine only" condition, are to be considered valid in good approximation even in the presence of lubricants.

**72-03-00 Limits**

**72-03-01 Operating Limits**

During the installation phase, it is necessary to measure various engine parameters, first on the ground and then in flight, verifying that in all operating conditions they comply with the values shown in the following table: the detailed tables according to the engine version are given in the operating manual. The installation and connection of the sensors necessary to verify the operating parameters (in flight) listed above must be performed by referring to the specific paragraphs in this manual.

<b>Maximum Revs [rpm]</b>	<i>Maximum power</i>	<i>Overrevs limit</i>
<i>Spirit 100 Direct R/L</i>	<b>3400</b>	<b>3500</b>
<i>Spirit 115 Direct R/L</i>	<b>3400</b>	<b>3500</b>
<i>Spirit 122 PSRU R/L</i>	<b>4200</b>	<b>4250</b>
<i>Spirit 135 Direct R/L</i>	<b>4700</b>	<b>4750</b>
<i>Spirit 135 PSRU R/L</i>	<b>4700</b>	<b>4750</b>
<i>Spirit 140 PSRU R/L</i>	<b>4200</b>	<b>4250</b>
<i>Spirit 160 Direct R/L</i>	<b>4700</b>	<b>4750</b>
<i>Spirit 160 PSRU R/L</i>	<b>4700</b>	<b>4750</b>

72-11-C

<b>Operating Limits</b>	<i>Min</i>	<i>Max</i>	<i>Typical</i>	<i>Max difference between banks</i>
<i>Maximum revolutions [RPM]</i>	---	---	---	---
<i>T water [°C]</i>	72	<b>102</b>	90	5
<i>T engine oil [°C]</i>	50	<b>130</b>	105	---
<i>T gearbox oil (+governor) [°C]</i>	20	<b>130</b> (130)	90 (105)	---
<i>T fuel [°C]</i>	---	<b>65</b>	40	---
<i>T air intake manifold [°C]</i>	-20	<b>75</b>	40	---
<i>T ECU [°C]</i>	-20	<b>80</b>	35	---
<i>T voltage regulator [°C]</i>	-20	<b>75</b>	40	---
<i>P engine oil [bar] (rpm&lt;2200)</i>	1,5 (0,8)	<b>4,5</b>	2,5 (1,5)	---
<i>P Fuel [bar]</i>	3,0	<b>3,6</b>	3,3	---
<i>Battery voltage [V]</i>	11,7	<b>15</b>	12,9	---

72-12-C

- The oil temperature is strongly influenced by the water temperature and is normally slightly higher than that of the water.
- Since the engine is provided with the thermostat on the cooling circuit, the change in the temperature of the cooling liquid between summer and winter is very limited, as long as the circuit is well done, letting the thermostat adjust the flow to the radiator during normal operation.
- The engine oil pressure is strongly influenced by the temperature of the oil: it is completely normal, therefore, to read high pressure values when oil is cold, and getting lower as the oil temperature rises. The oil circuit is protected from overpressure by a relief valve, which limits the maximum pressure to about 7.0 bar.

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- The minimum battery voltage shown is in normal flight conditions: in prolonged idle speed this voltage may be lower than the minimum reported without this implying damage to the charging system.



**Installations that cause the engine to overheat above these temperature values are absolutely to be avoided, as they are likely causes of engine failure.**



**If the temperature of the injection control unit exceeds the value shown in the table, the control unit is irreparably damaged, causing possible malfunctions in the engine. In this case it is essential to have the control unit checked at an authorized MWfly service centre.**



Flying above the maximum allowed RPM with the prolonged intervention of the electronic RPM limiter produces potential damage to the engine, which is difficult to diagnose. For this reason, in the event of prolonged use (greater than 15 seconds) under the limiter intervention regime, the engine must be subjected to a complete overhaul.



The cooling system must be designed to guarantee that the engine will work at a temperature that is lower than the max temperature indicated in the table in any operating condition. When the engine is operated outside of the parameter range indicated in the table the engine guarantee will be null and void and this will release the engine manufacturer from any liability.



In the event of over temperature, the injection system alarm light will turn on, signalling the critical condition: if this condition persists for more than 30 seconds, the injection system will record the event in the non-labile memory. During the revision this memory will be checked, and eventually the guarantee will be cancelled.



The injection system can continue to operate up to voltages of approximately 8.5 volts: however, in the event of voltage below the minimum reported during the cruise, it is advisable to land as soon as possible.

### 72-03-02 *Operating Limits of the Components*

In order to obtain the best performance from the engine, it is advisable to provide a flow of fresh air to the air filter, in running conditions with partialized gas, that provides air temperatures never higher than 35 ÷ 40 ° C in all weather conditions.

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The operating temperature of some components not directly cooled by the cooling system must also be limited to the values indicated below.

- |  |        |
|--|--------|
| ▪ ECU  | 85 °C  |
| ▪ Voltage regulator                              | 75 °C  |
| ▪ Start Relay                                    | 80 °C  |
| ▪ Gearbox  | 130 °C |
| ▪ Exhaust system                                 | 750 °C |
| ▪ Fuel pumps and filters, and fuel circuit pipes | 55 °C  |
| ▪ Shock absorber                                 | 80 °C  |
| ▪ Wiring loom                                    | 65 °C  |



**Flying with temperatures higher than the listed limits, affects the reliability and durability of the components and constitutes a cause of potential danger.**

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## 73-00-00 FUEL AND CONTROL

The fuel metering system consists of the injection system and the air intake system.



**Gasoline and gasoline vapours are highly flammable and harmful by inhalation. Any operation that takes place in the presence of gasoline or its vapours should be carried out in an open or well-ventilated place and away from open flames or heat sources.**

## 73-01-00 Air Intake System

### 73-01-01 Description

The intake system consists of an airbox and two manifolds (one for each bank): these pipes are connected to the airbox in a floating manner and to the heads through the interposition of gaskets; a temperature and pressure sensor for the supply air is fixed on the airbox; the throttle, the throttle control cam itself and the injection system potentiometer are housed in the lower part; a large air filter is fixed to the airbox inlet, kept in position by means of a hose clamp.



73-01-P

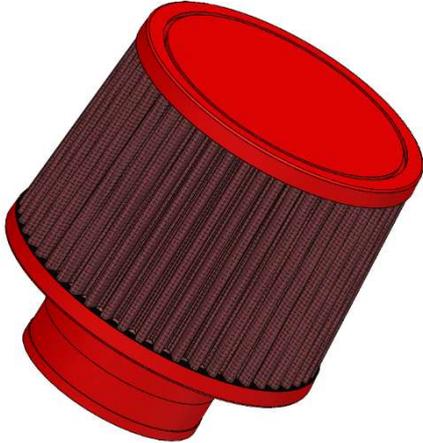


Any modification in the intake system causes imbalances in the power supply of the engine, and must be avoided.

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## 73-01-02 General Characteristics

### Air Filter



73-02-P

The original air filter, with cotton filter element, ensures the right filtering and flow to the engine, in order to obtain maximum performance. It is recommended to replace the filter at the scheduled intervals in order not to worsen the performance of the engine.

Another task of the air filter is to reduce the intake noise.



Under no circumstances run the engine without air filters: this can cause foreign matter to enter, resulting in serious damage to mechanical parts.

The main characteristics are listed below.

- Filtering element hydrophobic pre-impregnated multi-layer cotton fibre with reinforcing metal mesh
- Filtering surface  $\sim 1000 \text{ cm}^2$
- Filtration degree  $5 \div 10 \text{ }\mu\text{m}$
- Minimum flow rate (with  $\Delta P = 35 \text{ Pa}$ )  $19 \text{ m}^3/\text{min}$

### Manifolds

The length and arrangement of the intake manifolds has been calculated to obtain the best performance from the engine. For no reason change the length or section of the intake manifold, as it is a fundamental parameter for obtaining the rated power.



Changing the length or conformation of the intake manifolds alters the fluid dynamic efficiency of the powerplant, and thus both performance and carburetion. Any such modification can only occur if approved by MWfly in writing.

### Throttle Command

See section 76-10-00.

## 73-02-00 Removal and Installation of Vacuum System

### Necessary Materials

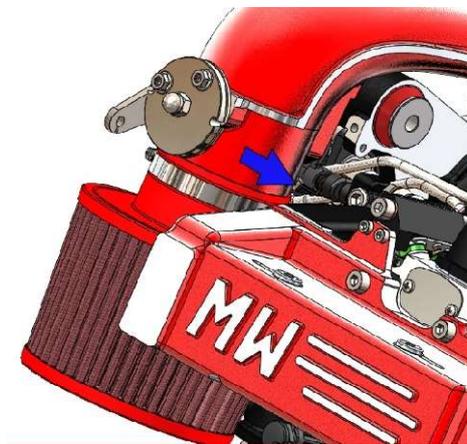
1. Torque wrench
2. 6 mm Allen wrench with ball head
3. 4 mm blade screwdriver
4. Cover for suction port

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To perform some installation operations, it is necessary to remove the intake system: for removal and subsequent installation, proceed as described below.

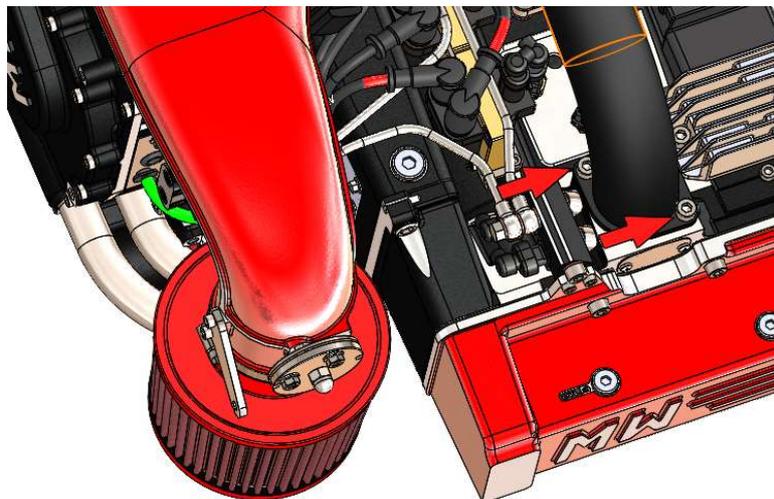
### 73-02-01 Removal

- a.** Remove the connector from the air pressure and temperature sensor by prying [3] below the present attachment clip on the connector.
- b.** Remove the connector from the throttle angle sensor by lifting [3] the clip located on the sensor itself.



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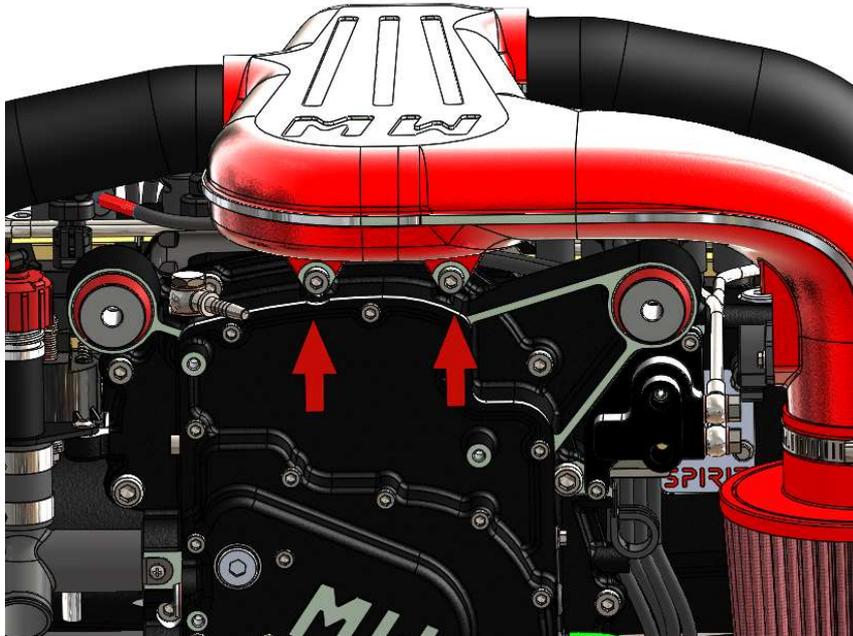
- c.** If necessary, remove the throttle control cable.
- d.** Unscrew [2] the two manifolds from the headers, progressively proceeding on both clamping screws. Be careful not to lose the gasket located below the manifold flange.



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- c.** Unscrew [2] the two rear airbox fixing screws.



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- d.** Protect the intake port on the cylinder head from the possible entry of foreign matter by inserting the appropriate plastic cover [3] or a clean cloth over the throttle valve.



Unless necessary, avoid moving or pulling the intake manifolds from their respective seats on the airbox.

### 73-02-02 Installation

Refer to the figures in the previous paragraph.

- Overlap the intake assembly to the headers and hold it in place by lightly screwing [2] the rear airbox screws.
- Place the two gaskets of the manifolds on the fixing plane located on each header, having previously checked their integrity: if they are damaged, they must be replaced.
- Insert the two fixing screws into the holes on each manifold; in case the holes on the second manifold do not match, it is necessary to introduce or extract it from its seat on the airbox.
- Tighten [2] the screws on the manifolds, starting with the innermost screw and proceeding progressively on both manifolds.

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- e. Tighten [1+2] the two rear M8 screws of the airbox to a torque of 22 Nm; in case the screws do not match the seat on the rear cover, it is necessary to slide the airbox over the two manifolds so that it is centred on the holes.
- f. Tighten [1+2] the two screws on each manifold, taking care to check that the plane of the manifold itself reaches the header plane: if not, slightly unscrew the rear airbox screws.
- g. Engage the connector on the air pressure and temperature sensor mounted on the airbox: check after engagement that the safety spring is properly engaged on the connector.
- h. Similarly, mount the connector on the throttle angle sensor, making sure that the safety clip is properly engaged.
- i. After the first ignition and warm-up, check the tightening [1+2] of the fixing screws and the possible presence of leakage from the gaskets on the cylinder head.

### 73-03-00 Criteria for the Construction of the Supply Air Intake

Engine performance is strongly influenced by the temperature of the inlet air: to this end, it is advisable to keep the inlet air temperature as low as possible, and therefore to provide one or more air intakes on the engine hood to ensure that fresh, oxygen-rich air flows to the intake filter, without it arriving after crossing hot surfaces (radiator or exhaust system).

The air intake must ensure the following characteristics in flight.

- Maximum in-flight power temperature 70 °C
- Minimum in-flight power temperature 0 °C
- Typical in-flight power temperature 25 °C
- Minimum inlet flow 0,35 m<sup>3</sup>/s

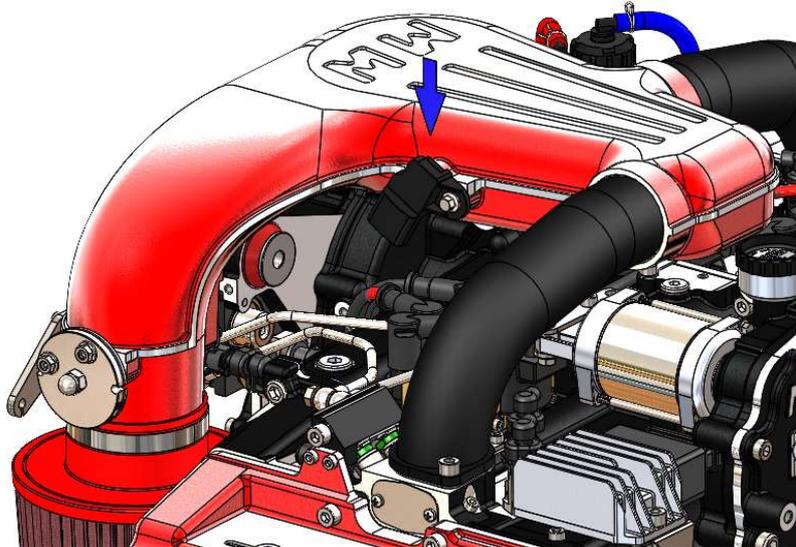
Avoid the direct impact of rainwater or foreign bodies on the filter. Also avoid making, so-called, dynamic air intakes, i.e., pressurizing the air before it enters the intake system: this, in addition to being unnecessary, can even become counterproductive in order to obtain maximum performance from the powerplant.

Injection fuel systems, as opposed to carburettor fuel systems, are unlikely to have icing problems; moreover, the raised and collected position of the throttle valve is specially designed to minimize any condensation of moisture in the intake system: for these reasons, it is not necessary in most installations, to make any special precautions to prevent the formation of ice in the intake ducts.

### 73-04-00 Verification and Validation

#### 73-04-01 Measurement of Supply Air Temperature and Pressure

The intake system airbox is equipped with a sensor for measuring the temperature and pressure of the intake air. This sensor is housed on the side of the airbox near the bank #1 manifold.



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The data provided by the sensor is transmitted to the injection control unit, which processes carburetion and advance adjustments according to these parameters.

In case an EM-m instrument or similar EFIS instrument connected to the ECUs in CAN mode is used, this data is available in the transmitted data protocol. Alternatively, a second air pressure sensor can be installed.

Tuning of the intake system should be accomplished as follows.

- a.** Carry out a test flight in warm weather (above 30 °C), verifying in flight that the temperature in the intake manifold does not exceed the ambient temperature by more than 10 degrees centigrade: if not, arrange appropriate air intakes to lower the temperature in the engine hood.
- b.** Carry out take off tests in warm weather (above 30°C), verifying that the MAP read at maximum rpm and at speeds above 90 km/h, is not less than the barometric pressure by 3 %.
- c.** If the pressure reading is lower, it is possible that the engine hood is working excessively under pressure, or, conversely, that the excessive overpressure is disturbing the pressure waves inside the manifolds. If this is the case it will be necessary to modify the air or exhaust vents on the hood.
- d.** Also check the condition and permeability of the air filter and replace it if necessary.
- e.** Once on the ground, turn off the engine and wait about 15 minutes.
- f.** Before restarting the powerplant, measure the temperature reached in the intake system, which must be below 75 °C to avoid difficult starts; if not, prepare an air vent at the top of the hood.

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### 73-04-02 Temperature Measurement of Components

The temperature of the engine components can be measured by placing irreversible adhesive thermometers on the surface of the components, which will detect the maximum temperature reached during operation or after shutdown. To perform this measurement, it is important that the installation is finished and the engine cowl is installed; perform a flight session, shut down the engine, and wait about 30 minutes; remove the engine cowl and note the temperature measured by the thermometers, which is the maximum temperature reached by the components (probably a few minutes after the engine is shut down).



In particular, the max temperature reached by the ECUs, current regulator, and starter relay should be checked since these are components particularly sensitive to the effects of overheating.

If any value exceeds the limits, it is necessary to increase the heat removal from the hood, either by letting in more air or by letting out the hot air formed inside the hood: for this purpose, it is advantageous to make openings in the upper part of the hood.

Surveys should be carried out with the highest possible ambient temperature in the operational area of the aircraft. If this is not possible, the increased heating of all components operating in warmer climates should be considered.



**When performing measurements on the engine and exhaust system take great care to avoid contact with hot surfaces, which can cause even serious skin injury.**

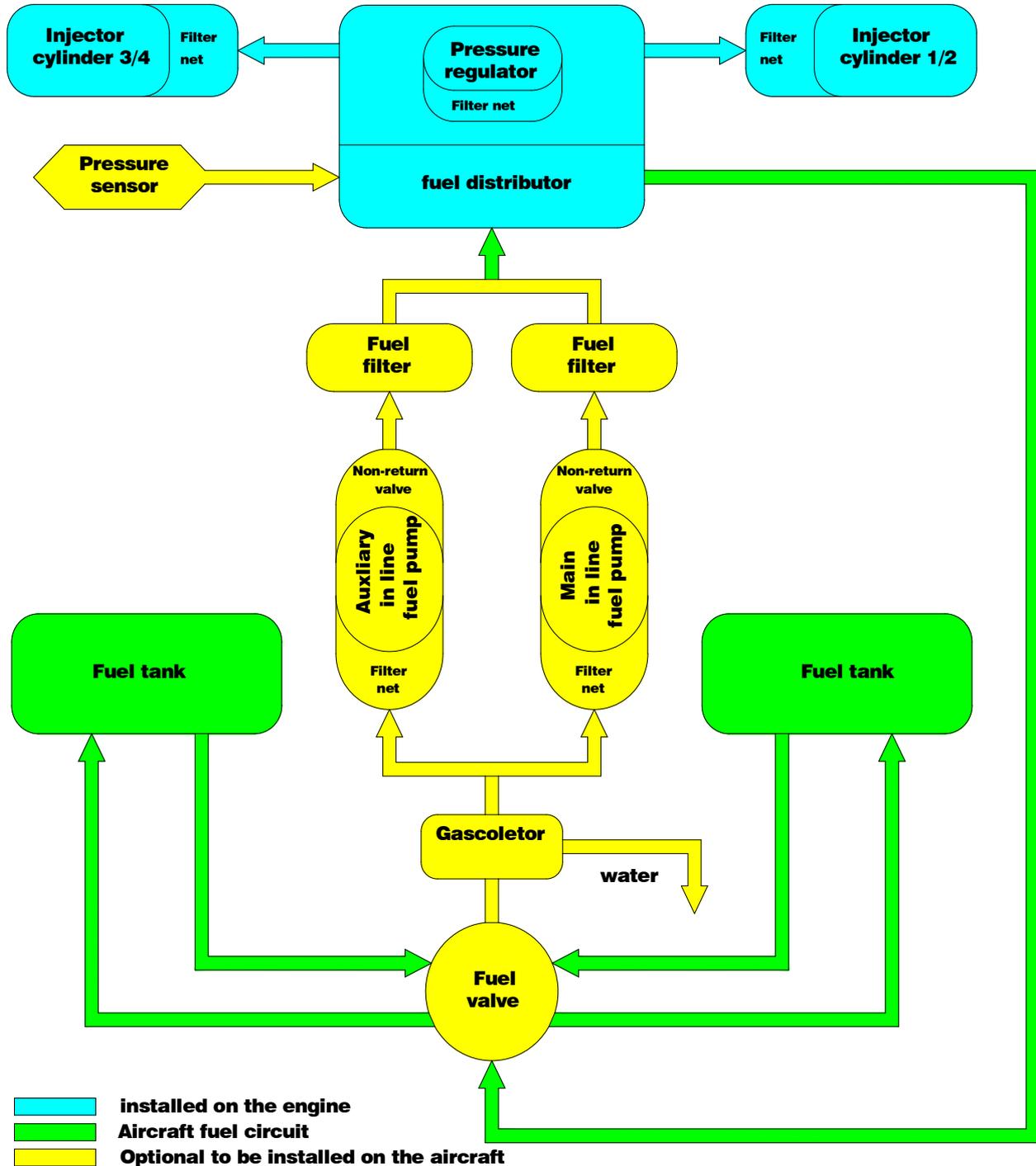


In case the limit on components has been exceeded for values above 10 °C, it is necessary to test them before using them again.

### 73-10-00 Fuel System

**SPIRIT** engines use a pressurized fuel injection system. The fuel supply pressure is regulated through a fuel pressure regulator, which is barometrically compensated. The fuel supply system is partly already installed on the powerplant, but must be completed by the installer in accordance with the diagram below.

**73-11-00 System Description**



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As shown in the diagram, the components of the system are as follows, listed along the direction of fuel flow.

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- Tanks
  - Fuel circuit valve
  - Water decanter filter (Gascolator)
  - Fuel pumps
  - Pressurized filters
  - Fuel distributor
  - Fuel pressure sensor (optional)
  - Fuel temperature sensor (optional)
  - Injectors
  - Pressure regulator

The components installed on the engine are as follows.

- Fuel distributor
- Pressure regulator
- Injectors
- Fuel distribution pipes to the banks
- Pressure sensor (optional)
- Fuel temperature sensor (optional)

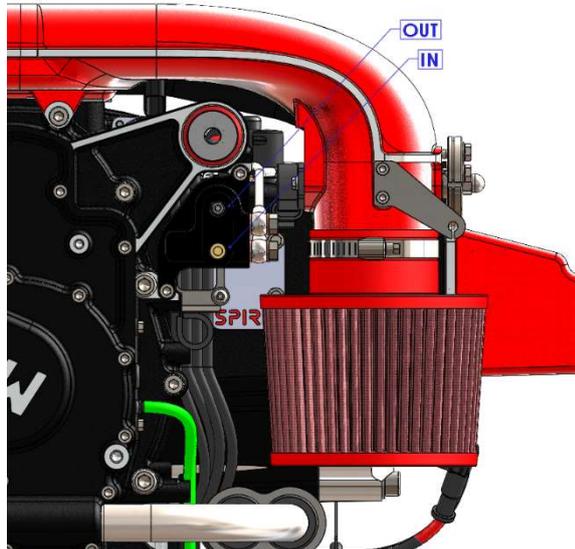
A pump and filter assembly called FD-m is available as an optional component, making installation work much easier.



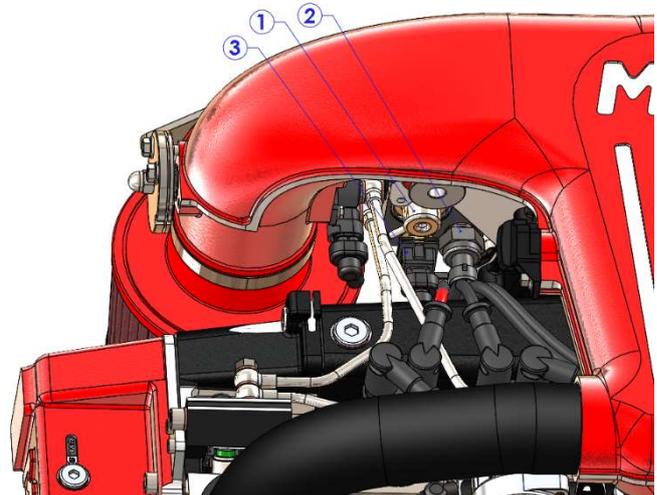
**MWfly does not authorize the use of fuel pumps and filters other than those prescribed.**

The fuel distributor is located at the rear of the crankcase on the right side. The pressure regulator (ref. 1) is installed on the distributor, which provides constant fuel pressure as conditions of use change. The pressure regulator is a mechanical component, so it does not require any electrical connection to function. In case of fuel pressure below or above the limits, malfunctions occur in the engine, starting difficulties, high fuel consumption or decrease in maximum power or unmotivated engine shutdowns: if this happens, it is necessary to restore the correct pressure before going into flight.

The pressure sensor (ref. 2) and fuel temperature sensor (ref. 3) can also be installed on the fuel distributor.



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Metal pipes for fuel circulation to the engine leave from the fuel distributor. Two pipes should be attached to the fuel distributor by the aircraft manufacturer: the first one carries the pressurized fuel coming from the pump (ref. "IN"), the second one (ref. "OUT") is the return to the tank of the excess fuel, i.e., not consumed by the engine, after passing through the pressure regulator: the fuel inlet and outlet ports are also identified by means of arrows placed on the fuel distributor itself.



The fuel inlet and outlet ports should not be interchanged as it would produce serious engine malfunction.

All other components of the system must be chosen and assembled by the installer, who will design and size the system.

### 73-12-00 General Characteristics

The fuel circuit characteristics must ensure the functionality of the powerplant within the operating limits:

- |   |         |
|---|---------|
| ▪ Maximum fuel pressure in flight       | 3,6 bar |
| ▪ Minimum fuel pressure in flight       | 3,0 bar |
| ▪ Typical in-flight fuel pressure       | 3,3 bar |
| ▪ Minimum fuel pressure for starting    | 2,7 bar |
| ▪ Maximum fuel temperature in flight    | 55 °C   |
| ▪ Typical in-flight fuel temperature    | 40 °C   |
| ▪ Maximum fuel temperature for starting | 65 °C   |

To ensure operation within the operating limits given above, it is very important to take care of the sizing of pipes and fittings, avoiding bends or particularly pronounced cross-sectional variations in the passages.

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The choice of system components must follow safety and serviceability criteria, and must comply with the requirements given.

## 73-13-00 Installation of Original Pump and Filter Module (FD-m)

### 73-13-01 Description

To facilitate the execution of the fuel system, the FD-m (Fuel Delivery module), available as an accessory, can be used. The unit consists of two pumps and two fuel filters, mounted in parallel inside a stainless-steel cabinet with cover and connected hydraulically and electrically.



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Quick latches are provided on the top of the cabinet to facilitate inspection before take off.

The position of the hydraulic connections on the locker can be changed according to the installation, bringing them both to the right, both to the left, or alternately one to the right and the other to the left. The hydraulic connection of the pump assembly to the aircraft fuel system is made through two fittings with M12x1.5 threading, both at the inlet and the outlet.

Attachment of the pump assembly to the firewall bulkhead is through 4 screws of 6 mm diameter, not supplied.

### 73-13-02 Component Characteristics

- |                         |               |
|-------------------------|---------------|
| ▪ Dimensions            | 344x136x74 mm |
| ▪ Fuel pump features    | Vedi 73-04-02 |
| ▪ Fuel filter features  | Vedi 73-04-03 |
| ▪ Threading of fittings | M12x1.5       |
| ▪ Weight FD-m           | 2,75 Kg       |

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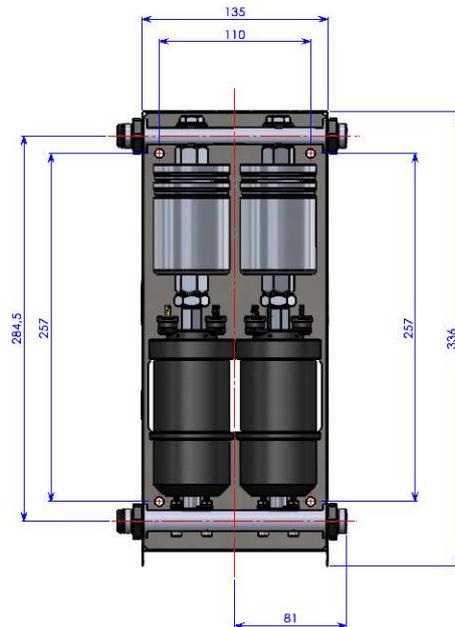
### 73-13-03 Installation

#### Necessary Materials

1. Torque wrench
2. 6 mm Allen wrench
3. 12 mm fixed wrench
4. 15 mm fixed wrench
5. 17 mm hex wrench
6. Phillips screwdriver
7. 6mm flat-blade screwdriver
8. Technical Vaseline
9. Other tools depending on the materials chosen during installation

The pump unit is already prewired; all connections inside the cabinet housing pumps and filters are made. To connect the unit to the system, simply proceed as follows.

- a.** Decide on the location of the pump assembly on the firewall, taking care to place it as far as possible from heat sources, as close as possible to the tanks, and in any case not more than 500mm above the lowest point of the fuel system. The pump unit should preferably be installed with the fuel inlet at the bottom or in a horizontal position.
- b.** Open the pump assembly cabinet by unscrewing the two knobs on the top.
- c.** Turn the front of the cabinet outward and release it from the two lower guide slots by pushing downward.
- d.** Based on the intended displacement on the gascolator and pump assembly firewall, decide how to arrange the inlet and outlet fittings on the pump assembly. The assemblies are delivered with both fittings arranged on the right; the connector is also on the right. In case you want to change this arrangement, simply change the position of the inlet or outlet pipe end caps located on the left side of the pump assembly, at the bottom (IN inscription) and top (OUT inscription), respectively. Re-tighten them [1+2] by tightening them to a torque of 35 Nm and holding the duct in place in the cabinet by engaging the appropriate wrench, [3] for upper pipe, [4] for lower pipe; the gasket washers must be replaced.
- e.** Drill [9] on the firewall the 4 fixing holes at the spacing shown in the figure.



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The type of fasteners to be used and the resulting hole diameter of the flame guard are at the discretion of the installer; the holes on the pump assembly are 6.5 mm in diameter; it is not necessary to provide elastic elements for fastening.

- f.** Attach the cabinet to the flame shield by tightening the fasteners to the prescribed torque; if screw fasteners are used, a threadlocker compound should be used on the threads.
- g.** Decide on the optimal position (left or right) for the pump control connector and attach it to the cabinet. Before attaching it, widen outward with a screwdriver [7], the two edges of the connector's attachment territory at the top, to make it easier to insert.
- h.** Connect the aircraft-side wiring loom, which will have been prepared in advance, to the connector; the counterpart connector on the cabinet is supplied with the pump assembly.
- i.** Insert the fuel hose coming from the gascolator into the fitting hose holder, and secure it [6] with a hose clamp; if necessary to facilitate insertion, use denatured alcohol or Vaseline [8].
- j.** Connect the fuel inlet branch at the bottom of the cabinet, coming from the gascolator, by placing a gasket washer above and below the fitting eye. Tighten [1+3] to a torque of 35 Nm. While tightening, rotation of the manifold must be prevented by holding it in place with an appropriate wrench [4].
- k.** Apply the same operations to connect the fuel outlet branch: in this case, to prevent rotation of the manifold, use wrench [3].
- l.** Although all FD-m assemblies are verified at the factory after assembly, it is necessary to reverify there are no leaks by turning on the fuel pumps after finishing the installation.

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**m.** Close the cabinet by inserting the lower part of the cover into the guide slots and screwing the two retaining knobs to the top by hand.



**Before starting the engine, check all elements of the pump assembly and fittings for leaks under pressure: if necessary, open the cabinet cover to make sure there are no leaks inside.**

### 73-14-00 Implementation of the Fuel Circuit



The gasoline circuit must comply with any regulations in force in the country where the powerplant is used. The user acknowledges that he/she is responsible for proper installation and perfect compliance with applicable regulations.

#### 73-14-01 Gascolator

The gascolator is not part of the standard equipment: the choice should be made in accordance with the characteristics summarized below.

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>▪ Type</li> <li>▪ Casing material</li> <li>▪ Minimum glass capacity</li> <li>▪ Operating pressure</li> <li>▪ Filter element material</li> <li>▪ Minimum filtering capacity</li> <li>▪ Number of connections</li> <li>▪ Tube holder diameter</li> </ul> | <ul style="list-style-type: none"> <li>gascolator with wire mesh filter and purge valve, suitable for use with green gasoline metal (avoid glass)</li> <li>0,15 L</li> <li>-0,1 ÷ 0,2 bar</li> <li>metal</li> <li>70 µm</li> <li>1 inlet + 1 outlet</li> <li>8 mm</li> </ul> |
|---|--|



Before each flight, purge the decanter filter of any accumulated water.

#### 73-14-02 Fuel Pump



A safe installation involves mounting two fuel pumps, connected to each other in parallel.



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Fuel pumps are supplied as an accessory. Alternatively, the FD-m accessory, in which two fuel pumps are already installed and connected to the respective filters, can be mounted. In any case, the characteristics of the pumps are as follows.

- |  |              |         |
|--|--------------|---------|
| ▪ Fuel flow                                    |              | 100 l/h |
| ▪ Static pressure rating                       |              | 5,5 bar |
| ▪ Max priming height                           |              | 500 mm  |
| ▪ Supply voltage                               |              | 12 V    |
| ▪ Corrent load                                 | Max          | 9 A     |
|  | at P=3,5 bar | 5,5 A   |
| ▪ Inner diameter of suction tube               |              | 12 mm   |
| ▪ Outlet side threading                        |              | M10x1   |
| ▪ Outlet side tightening torque                |              | 17 Nm   |
| ▪ Minimum length of pipe insertion on fittings |              | 20 mm   |
| ▪ Positive pole eyelet terminal diameter       |              | 4 mm    |
| ▪ Negative pole eyelet terminal diameter       |              | 5 mm    |
| ▪ Weight                                       |              | 660 g   |

### 73-14-03 Fuel Filter



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- |                              |                      |
|------------------------------|----------------------|
| ▪ Fuel flow                  | 90 l/h               |
| ▪ Filter capacity            | 10 µm                |
| ▪ Filter surface area        | 1200 cm <sup>2</sup> |
| ▪ Filter material            | paper                |
| ▪ Maximum operating pressure | 6 bar                |
| ▪ Operating temperature      | -40÷90 °C            |
| ▪ Inlet port                 | M16x1.5              |
| ▪ Outlet port                | M16x1.5              |
| ▪ Weight                     | 126 g                |

The fuel filter should be installed after the two fuel pumps: the presence of the fuel filter is essential to ensure the protection of the injectors from the entry of fine particulate matter, which would damage them.



**Replace the fuel filter at the intervals specified in the routine maintenance schedule: failure to replace may result in poor performance or sudden engine shutdown.**

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### 73-14-04 Pipes and Fittings

Material with the minimum characteristics listed below must be used to make the fuel circuit.

- |  |        |
|--|--------|
| ▪ Inner diameter of fuel delivery tubes    | 8 mm   |
| ▪ Inner diameter of fuel suction tubes     | 8 mm   |
| ▪ Minimum continuous operating temperature | 80 °C  |
| ▪ Minimum continuous operating pressure    | 5 bar  |
| ▪ Minimum burst pressure                   | 10 bar |
| ▪ Minimum radius of curvature              | 50 mm  |
| ▪ Minimum pipe inlet length on the fitting | 20 mm  |

### 73-14-05 Fuel Valve

Although not essential for engine operation, the adoption of a valve in the fuel system increases its safety and facilitates maintenance operations. In the case of single-tap or compensation nourisse installations, a single-way valve can be installed, which then intercepts the flow of only the fuel inlet branch to the engine. In the case of dual-tank installations, the valve must intercept both the fuel intake branch from the tank and the excess fuel return branch to the tank: this obviously applies to both tanks. Otherwise, since the flow rate of the pump is clearly in excess of the actual consumption of the powerplant, the excess fuel would indiscriminately return to both tanks, causing the tank in use to be emptied in a short time. The characteristics of this component should be as follows.

- |                      |                              |
|----------------------|------------------------------|
| ▪ Positions          | closed, right, left, both    |
| ▪ Rotation angle     | 360° without end stop        |
| ▪ Number of ways     | 2, supply and return to tank |
| ▪ Operating pressure | 3,5 bar                      |
| ▪ Burst pressure     | >>10 bar                     |

These specifications are to be considered as the minimum to be used.



In the event of an accident and capsizing of the aircraft, it is important that the fuel contained in the tank cannot spill out: for this reason, even on single-tank installations, we still recommend adopting valves that also intercept the return branch to the tank or, alternatively, equipping this branch with a check valve.

### 73-14-06 Circuit Implementation

#### Necessary Materials

1. Torque wrench
2. Hexagonal wrench 14 mm
3. Hexagonal wrench 19 mm
4. Hexagonal wrench 24 mm
5. Weak threadlocker

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6. Other tools depending on the materials chosen during installation

- a.** Attach a fuel pipe line tube, of the prescribed type, to each wing tank, taking care to secure it elastically to the plates of the aircraft without allowing it to rub against sharp surfaces or edges. For safety reasons, fuel tanks should have a sump for water, which should be purged before each flight. If the aircraft is equipped with a nourisse (cabin tank), the fuel sump tube should be attached to the latter.



**Use only metal clamps with rounded edges when tightening pipes to their respective tube holders.**

- b.** On each line or the intersection of the two lines interpose a fuel valve. The valve can be any of the two-position (on, off), three-position (on right, off, on left), or four-position (on right, off, on left, both) type.



**If the three-position valve is used, switching from one tank to the other with the engine running must be done very quickly, to avoid the risk of shutting down the powerplant by switching to the off position.**

- c.** Attach a water decanter filter (Gascolator) to what will be the lowest point in the entire fuel system. This component protects the fuel pumps and engine from any water in the fuel. The size of the sump determines the maximum running time of the engine with the fuel valve closed: by way of example, remember that a sump volume of 100ml allows the engine to run at full power for about 10 seconds. To facilitate before flight operations, it is recommended that the decanter filter be mounted in a location that can be easily inspected, even once the engine cowling is installed.



**The gascolator must necessarily be installed before the pumps, as it cannot work under pressure.**

- f.** Connect the gascolator to the valve by means of rubber tubing of the prescribed type, taking care to secure it so that it is higher than the bottom of the decanter.

- g.** Elastically attach the fuel pumps to the aircraft.

- h.** On the pumps, the inlet side has a hose holder for hoses with an internal diameter of 12 mm; on the outlet side, on the opposite face, there is an M10x1 thread. The pumps must be positioned no more than 500 mm above the bottom of the gascolator in order for them to ensure fuel priming: however, it is a good idea to keep them as close to the gascolator as possible and in an upright position, with the fuel inlet port at the bottom and the outlet port at the top. If two pumps are used, they should be connected in parallel by installing T-connections on the inlet and outlet.

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- i.** The pumps are of the non-transparent type, i.e., they do not allow fuel to flow to the engine if they are off; a check valve is also built into them to prevent the system from losing pressure when the pump is off.
- j.** Refer to the diagram in this manual for the electrical connections of the pumps.
- f.** After the T-connection joining the outlet ports of the two pumps, attach the pressurized filter elastically in an easily accessible area for possible periodic replacement. The inlet port (IN) and outlet port (OUT) fuel and the direction of flow (arrow) are clearly marked on the filter. The location of the filter is irrelevant to the proper operation of the powerplant. The minimum tube insertion length on the filter body is 14 mm.



**Use only fuel filters suitable for mounting on pressurized circuits and suitable for use with green gasoline.**

**g.** Connect the gascolator to the pumps with piping of the prescribed type and the pumps to the pressurized filter, taking care to use new metal clamps of adequate diameter. The tightening torque [1+6] of the outlet line from the fuel pump should be 17 Nm: when tightening, it is advisable to counteract the action of the torque with a wrench [2] engaged on the hexagon on the outlet port of the pump itself, so as not to risk damaging the seals. It is also advisable to use weak threadlocker [5] on the threads to ensure better sealing against vibration.

**h.** Connect the pressurized filter to the fuel distributor located at the rear of the engine using prescribed fuel hose. Another pipe should be connected from the distributor to the fuel valve; the fuel valve should in turn be connected to both wing tanks, also regarding the fuel return.



**Use only gasoline hoses approved for pressurized circuits, with an inner diameter of 8 mm, of the type resistant to green gasoline. Replace them every two years.**

In case the aircraft is equipped with a manifold tank between the two wing tanks (nourisse), the fuel return branch from the engine can also be connected to this tank, possibly interposing a check valve, which will prevent in case of tipping and rupture of the piping the fuel from the tanks in the direction of the engine; this valve should be installed as close as possible to the tank itself.

The pipes must be connected to the distributor through connections with M12x1.5 thread. The tightening torque of the fittings must be 35 Nm and the fittings must engage in the thread for at least 8 mm.

Fasten the hoses to the aircraft in an elastic manner, taking care to ensure that they are not stretched or excessively loose during engine operation. If necessary, protect the external surface of the pipes with a silicone sock, to improve resistance to heat and abrasion.

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The system provides a return line for excess fuel to ensure a constant supply of pressure and to prevent vapour-lock phenomena (formation of hydrocarbon vapor bubbles in the fuel circuit, caused by excessive heating). The pressure in the fuel circuit is usually sufficient to avoid the risk of vapour lock, either in flight or at start-up after a short stop. For the same purpose, the system provides two lines, one to carry fuel to the engine, the second to return excess fuel from the engine to the tanks. If vapour lock occurs, it is advisable to protect the fuel lines with refractory conduits and increase ventilation in the engine cowl.

- i.** Screw [4;5] the pressure sensor to the fuel distributor, if any (available as an accessory), tightening [1+4] to a torque of 30 Nm, using an annealed copper washer as a gasket. The predisposed thread is 1/4" gas.



**The sensor to be used must be specifically suitable for installation in systems with green gasoline: using unsuitable sensors may result in puncture of the sensing membrane, with fuel leakage and serious fire hazard.**

- j.** Also screw [3;5] the fuel temperature sensor to the fuel shunt, if any (available as an accessory), tightening [1+3] to a torque of 20 Nm and using an annealed copper washer as a gasket. The threading is M14x1.5.
- k.** Bleed the fuel system.



**Before starting the thruster, turn on the pump and verify the presence of the rated pressure in the circuit, proper electrical absorption, and the absence of leakage: in particular, verify there are no leaks, even minimal, from the sealing washers and the area where the tubes are inserted in the distributor.**



In case of prolonged engine shutdown, it is necessary to check the proper functioning of the fuel pumps and injectors: in fact, they may be damaged or blocked by fuel residue, making starting difficult or impossible.

- l.** Connect the positive cable coming from the pump relay to the small terminal of the main pump, after threading the protective cap provided on the cable and terminating it with a D4 mm eyelet terminal.
- m.** Connect the positive wire coming from the auxiliary pump switch to the small terminal of the auxiliary pump, after threading the protective cap provided on the wire and terminating it with a D4 mm eye terminal.

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- n.** Connect two leads to the large terminal of both pumps, after threading the protective caps provided on the leads and terminating them with D5 mm eyelet terminals.
- o.** Connect the other end of the negative cables from the pumps to chassis ground.
- p.** Tighten all the nuts of the positive terminals to a torque of 3 Nm, and the negatives to a torque of 5 Nm, interposing the safety washers provided.
- q.** Stocking the protective caps on the terminals of the pumps: in case of difficulty, sprinkle a layer of Vaseline on the surfaces.



Avoid operating the fuel pumps for a long time without fuel as they may overheat and become irreparably damaged.

### 73-15-00 Recommended Fuel

The engine is constructed with components suitable for the use of commercial automotive gasoline. The minimum characteristics of the fuel to be used are as follows:

- Green gasoline RON 95 or higher
- Red gasoline 95 octane or higher



**The use of AVGAS gasoline has not been verified during testing: do not use this type of fuel for any reason, as it could severely damage the injectors and the engine to the point of causing it to shut down.**



Using fuel with anti-knock characteristics lower than prescribed can cause damage to the mechanical components of the engine. If such fuels are accidentally used, a thorough inspection of the combustion chamber, pistons, head gasket and crankshaft should be carried out.



The formulation of gasoline varies between summer and winter; therefore, it is important to make sure to use fuels prepared for the climatic condition in which the engine operates.

Avoid storing fuel for a long time and using winter fuel in summer. Summer fuel has less aptitude for evaporation as more volatile components are removed: this decreases the risk of vapour lock in the fuel system.

### 73-16-00 Filling the Fuel System

When the pumps are first turned on, or in case work has performed on the fuel system, it is necessary to blow out the air contained in the fuel hoses.

To bleed the system, it is necessary to turn on the auxiliary fuel pump for a few seconds, until a change in the noise emitted by the pump is detected: at this point

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the correct operating pressure (about 3.3 bar) should be read on the instrument. In case that even after more than 10 seconds after starting the pump, this does not occur, turn off the pump itself to avoid damaging it and proceed as described below. At this stage it is necessary to get help from a second person and operate in an open environment away from heat sources.

### Necessary Materials

1. Torque wrench
  2. 12 mm hex wrench
  3. Blotting paper
- a.** Slightly unscrew [2] the fitting of the fuel lines on the #1 bank header, wrapping [3] with paper towels around the space, so as to avoid fuel gushing.
  - b.** Engage the appropriate wrench [1+2] on the fitting connection tightening screw to be ready for re-tightening.
  - c.** Operate the auxiliary fuel pump.
  - d.** As soon as fuel is leaked from the loose connection, retighten it to the prescribed torque (15 Nm).
  - e.** Promptly wipe up any leaked gas with the paper towels [3].
  - f.** Repeat the same operations on the header of bank #2.
  - g.** Operate the pumps again and perform the system pressure check.

### 73-17-00 Verification and Validation

Proper operation of the powerplant requires that the system can deliver the appropriate amount of fuel under all environmental and flight conditions. Unlike carburetor fuel systems, the electronic fuel injection system ensures smooth and safe operation as the aircraft lay, during maneuvers, and as environmental conditions change.

For these reasons, tuning the fuel system does not present any particular difficulties or critical issues: however, it is important to perform some checks during the first hours of operation, summarized below.

#### 73-17-01 Fuel Houses

After the first few hours of operation, it is essential to completely remove the engine cowlings and check for signs of fuel leakage, usually evidenced even when dried by a green residue of gelatinous appearance. It is also important to check the inner surface of the cowlings, as the flow created by the propeller could disperse any leaks.

If there are any leaks, even small ones, do not operate the aircraft or start the propeller again until the leak is located and removed. Carefully check all fittings in the fuel circuit, and the tightness of the connections or clamps provided. If in doubt, do not hesitate to replace the clamps or seals.

Another important check is to be made on the hoses: in particular, their outer surface should be checked for bulges (an unmistakable sign of overheating) or abrasions (a

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sign of contact with engine or aircraft surfaces). If the hose is damaged, it is essential to replace it and modify the passage or attachment on the aircraft. It is also possible to use silicone sheaths to protect the tubes, which protect them from heat and abrasion. The tubes should not be in tension or excessively loose, a sign that they have shifted from their original position: if so, check and, if necessary, modify their attachment.

### 73-17-02 Fuel Pressure Measurement

Fuel pressure can be measured by installing the pressure sensor in the housing provided on the fuel distributor (1/4" gas thread).

The verification of system pressure should be carried out as follows.

- a.** Install the pressure sensor.
- b.** Purge the fuel system.
- c.** Power up the injection system and verify that the main pump is running for about 2.5 seconds.
- d.** When the main pump is turned off, check that the system is pressurized to at least 2.7 bar. If it is not, turn off the injection system, wait about 10 seconds, and then turn it on again. Check the system pressure: if the minimum expected pressure has not been reached, check for leaks or obstructions in the system.
- e.** Wait about 5 minutes: the pressure in the fuel system should drop no more than 0.5 bar every minute. If it drops more, it is likely that there are leaks or that the check valves inside the pumps are defective.
- f.** Power up the auxiliary pump, if provided, and repeat the checks implemented for the main pump.
- g.** Start the engine and check that the system pressure is between 3.0 and 3.6 bar. If this is not the case, do not flight.
- h.** With the engine running, switch on the auxiliary pump: check that the pressure, increases by no more than 0.4 bar. If the increase is greater, it is necessary to increase the diameter of the return line to the tank.

### 73-17-03 Fuel Temperature Measurement

The fuel supply system is pressurized and has a return line to the tank: these features make vapour lock phenomena very unlikely. However, it is advisable to verify that the fuel present on the pressurized branch never exceeds 55 °C during use, and 65 °C at start-up.

The verification should be carried out as follows.

- a.** Perform a test flight in warm weather (above 30 °C), checking in flight that the temperature is within the expected limits: if not, prepare appropriate air intakes to lower the temperature in the engine hood.
- b.** Once on the ground, turn off the engine and wait about 15 minutes.

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- c.** Before restarting the engine, measure the temperature reached by the fuel, which must be below 65 °C to avoid vapour lock phenomena that would make restarting difficult
- d.** In case the engine has difficulty restarting, run the auxiliary pump for at least 5 seconds, and try starting the engine again.
- e.** In any case, if the fuel temperature exceeds the prescribed limits on the ground, it is advisable to thermally insulate the fuel lines with fireproof material, move them away from heat sources, and provide an opening at the top of the engine cowling to facilitate the venting of hot air.



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Particular care must be taken in the ventilation of the exhaust system, which is thermally stressed: if the original exhaust system is used, the hottest part is the one near the junction of the manifolds in the muffler.

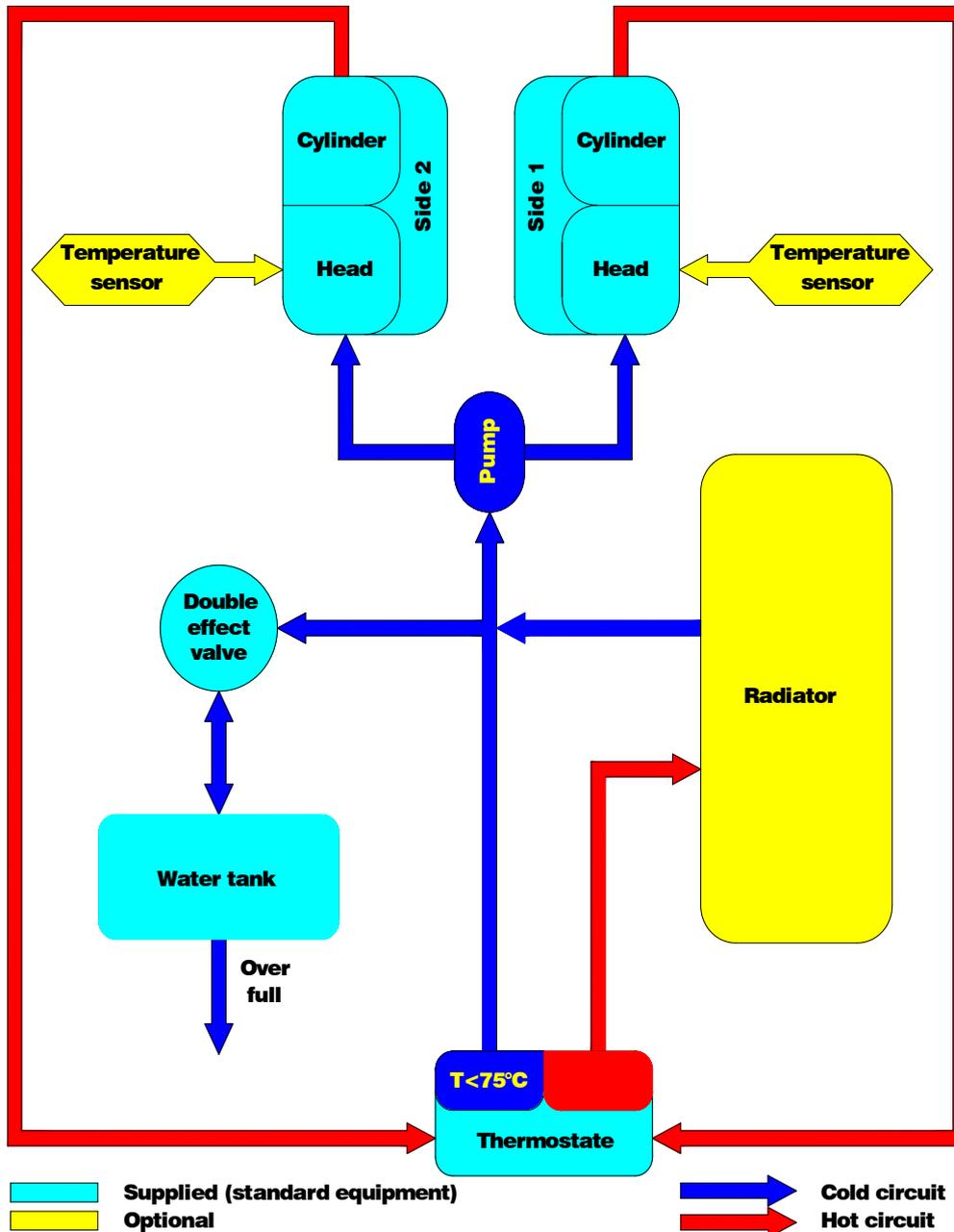
In case the cooling water radiator is mounted in front of the exhaust system, it is sufficient for the air leaving the radiator to pass over the muffler to ensure adequate heat removal. Also check the thermal condition of the exhaust manifolds near the cylinder head, and if necessary, make small air intakes near them.

In case the injection control unit is installed in the engine cowling, it is also necessary to provide one or more air extraction openings in a high position on the cowling itself, to facilitate the evacuation of air even when the aircraft is stationary: in this way it is possible to avoid possible overheating of the injection control unit after engine shutdown, caused by the accumulation of hot air in the cowling.

### **75-20-00 Liquid Cooling System**

**SPIRIT** engines are completely liquid-cooled: this choice was made because it improves the reliability and consistency of the engine's performance compared to the simpler air-cooling system but also more critical both in installation and in use. In fact, with liquid cooling, the thermal stability of the engine is improved under all conditions, for example, during long idle runs or during long waits for take off. The adoption of liquid cooling, by improving the cooling of critical points in the engine, also allows higher specific power outputs to be achieved than is possible with air cooling.

## 75-21-00 System Description



The cooling system is of the pressurized closed-circuit type with integrated relief valve, thermostat and expansion tank. Coolant is sent from the pump keyed on the crankshaft to the cylinder heads through separate stainless-steel ducts: as it exits the cylinders it passes through the thermostat, installed inside the pump cover. When the engine is cold, the thermostat intercepts the flow, short-circuiting the return of the liquid from the cylinder block with the pump inlet manifold, so that the radiator is excluded from the circuit; when the coolant reaches about 75°C, the thermostat

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gradually opens the passage to the radiator: in this way the engine reaches the correct operating temperature more quickly and is less sensitive to variations in load and speed. The bleed valve is at the inlet line of the water pump, which pours excess liquid back into the expansion tank when it is opened; a second valve allows the liquid accumulated in the expansion tank to re-enter the circuit as a result of the vacuum created during the cooling phase of the thruster.

The coolant provides heat removal from both the cylinder heads and the cylinders. Specifically, the coolant enters the cylinder head and exits the cylinders after lapping the outer wall of the liners. The only connections that need to be made in order to use the engine are between the radiator and the inlet and outlet manifolds from the water pump.

The cooling system is set up to connect a heating radiator for the cabin.



The cooling circuit is pressurized: when the engine is hot, avoid removing the red filler cap.

### 75-22-00 General Characteristics

- |   |                  |                     |
|---|------------------|---------------------|
| ▪ Maximum coolant temperature in flight                 |                  | 102 °C              |
| ▪ Minimum coolant temperature in flight                 |                  | 72 °C               |
| ▪ Typical coolant temperature in flight                 |                  | 90 °C               |
| ▪ Minimum hangaring temperature<br>(mixture 30% glycol) |                  | -18 °C              |
| ▪ Water pump rated flow rate                            |                  | 96 l/min @ 3200 rpm |
| ▪ Maximum heat to be removed                            | (Spirit 100 R/L) | 27,3 kW             |
|   | (Spirit 115 R/L) | 31,6 kW             |
|   | (Spirit 122 R/L) | 33,3 kW             |
|   | (Spirit 135 R/L) | 37,0 kW             |
|   | (Spirit 140 R/L) | 38,8 kW             |
|   | (Spirit 160 R/L) | 44,2 kW             |
| ▪ Thermostat opening start temperature                  |                  | 75 °C               |
| ▪ Thermostat end opening temperature                    |                  | 88 °C               |
| ▪ Filling cap valve opening pressure                    |                  | 1±0,05 bar          |
| ▪ Depression opening valve filler cap                   |                  | 0,05 bar            |



Operating the engine with coolant temperatures above the maximum operating limits can facilitate the onset of detonation, a very destructive phenomenon for the engine.

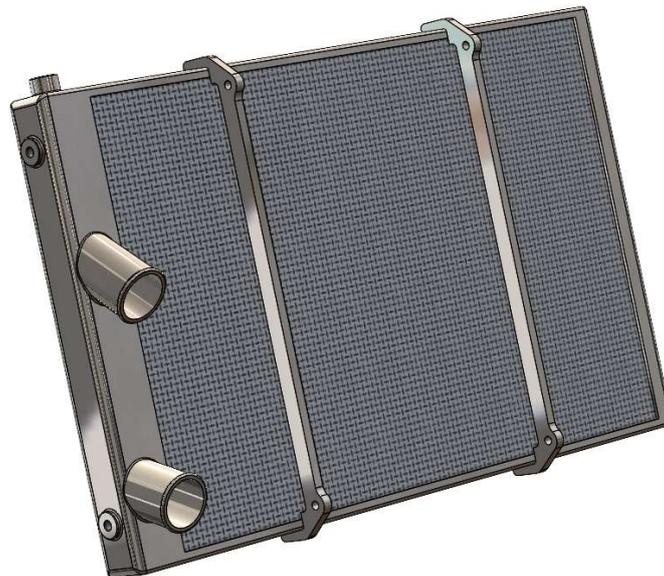
### 75-22-01 Capacity

- |                               |          |          |
|-------------------------------|----------|----------|
| ▪ Crankcase                   |          | 2x0,53 l |
| ▪ Heads                       |          | 2x0,4 l  |
| ▪ Water pump                  |          | 1,05 l   |
| ▪ Filling pipe and pump pipes |          | 0,23 l   |
| ▪ Expansion tank              | max      | 0,7 l    |
|                               | standard | 0,45 l   |

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- Distribution pipes 0,51 l
- CR-m STD radiator 0,8 l
- CR-m STD radiator hoses 0,4 l
- Total quantity in the engine 3,7 l
- Total quantity in the engine with CR-m STD 4,9 l

### 75-23-00 Cooling Radiator Module (CR-m STD)



75-01-P

A cooling radiator and manifold assembly, called CR-m STD (Cooling Radiator module standard), is available as an option. The radiator, made entirely of aluminum, is suitable for most tractor applications, and ensures adequate cooling of the engine, provided that an efficient air intake is made under all operating conditions and that it is able to divert the airflow in a direction orthogonal to the plane of the radiator.

#### 75-23-01 Description

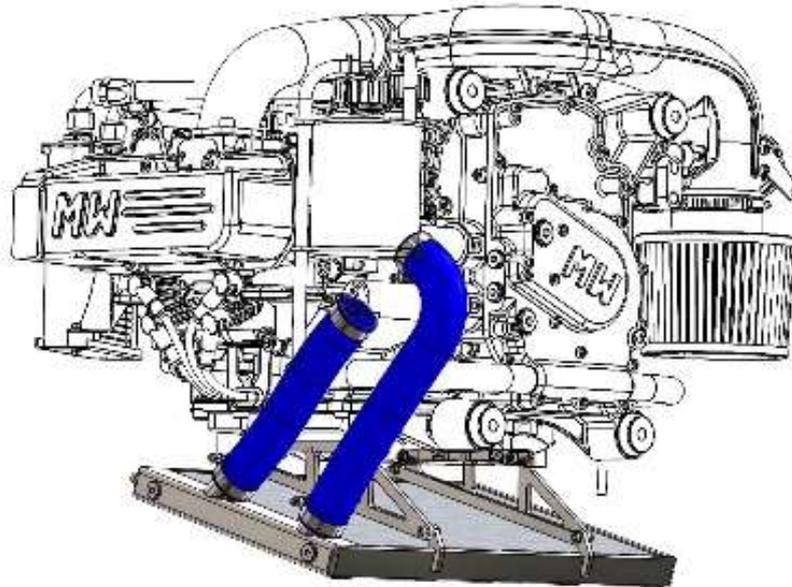
The radiator is supplied with fittings and small parts for connection to the engine: these components are made in integral form (without joints) of silicone rubber; they are able to withstand temperatures close to 250 °C, and thus withstand without any damage the temperatures induced by the proximity of the exhaust manifolds (as long as they are not in contact with them).



In order to ensure the proper safety of the installation, rubber or plastic fittings must be replaced at the scheduled intervals, as they are sensitive to the action of ozone and ultraviolet rays.

The radiator is fixed in the lower part of the engine, at the oil sump, by means of anti-vibration elements, supplied with the radiator itself, and is inclined with respect to the

propeller axis: this solution avoids soiling of the radiator and decreases the frontal section of the hood, without penalizing heat exchange too much.



75-02-P

### 75-23-02 Component Characteristics

▪ Radiator dimensions	460x270x30 mm
▪ Radiator cooling surface	1100cm <sup>2</sup>
▪ Typical cooling flow on the radiator	1,65 m <sup>3</sup> /s
▪ Inner diameter of refrigerant tubes	32 mm
▪ Refrigerant quantity in radiator and tubes	1,2 l
▪ Weight CR-m STD	2,1 Kg

### 75-23-03 Installation

#### Necessary Materials

1. Hexagonal socket screwdriver 7 mm
2. Vaseline
3. 3 mm Allen wrench

The installation of the radiator is done as follows.

- a.** Attach the four elastic elements (silent blocks) to the holes on the oil pan, taking care to tighten them until they are flush with the work surface; tightening should be done by hand, applying a moderate load.
- b.** Slip the two silicone hoses onto the radiator, taking care to position the curved one on the lower manifold, as in the figure; if necessary, use Vaseline [2] to facilitate their introduction.



75-03-P

- c.** Secure the fittings on the manifolds by tightening [1] the supplied clamps on the hoses to a torque of 5 Nm; tighter tightening unnecessarily stresses the pipes.
- d.** Remove the protective covers present on the pump manifolds.
- e.** Attach the radiator to the underside of the engine, fitting both hoses onto the respective manifolds at the rear of the engine; if it is difficult to introduce, use Vaseline [2].
- f.** Attach [3] the radiator to the four spring elements underneath the oil pan using the screws provided; the screws should engage the vibration-damping elements for the first stretch without strain, after which a fair amount of strain should be felt, determined by the fact that the screw penetrates the rubber thus averting any accidental unscrewing; the screws should be brought to a stop on the radiator support bracket and tightened with a moderate load.
- g.** Secure the fittings on the water pump manifolds by tightening [1] the supplied clamps on the hoses and carry out set-up.

## 75-24-00 Realization of the Engine Cooling Circuit

### 75-24-01 Pipes and Fittings

The characteristics of the pipes and fittings of the cooling system should be as follows.

- |   |       |         |
|---|-------|---------|
| ▪ Minimum continuous operating temperature  |       | 125 °C  |
| ▪ Minimum continuous operating pressure     |       | 1,5 bar |
| ▪ Hoses inner diameter                      | ideal | 32 mm   |
|   | min   | 25 mm   |
| ▪ Minimum radius of curvature               |       | 50 mm   |
| ▪ Minimum hoses inlet length on the fitting |       | 20 mm   |

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- Use hoses suitable for ethylene glycol and anti-ozone; in any case, change the system hoses at least every 2 years
- Use sealing ties with rounded edges, so as to avoid notching the outer surface of the fittings; after the first heating cycle of the engine carry out re-tightening of the sealing ties.

### 75-25-02 Radiator

The shape, size and location of the radiator depend mainly on the space available. In special cases, it is also possible to use two radiators instead of one.

- Typical radiator cooling surface ~880 cm<sup>2</sup>
- Typical cooling flow on the radiator 1,5 m<sup>3</sup>/s

The radiator should be installed so that the inlet connection is at least 100 mm below the pressurized cap located at the inlet of the expansion tank. If this is not possible, a radiator equipped with a 1-bar vent cap and vacuum valve should be used, and an expansion tank to which the liquid escaping from the cap should be directed. The outlet connection from the radiator should be no more than 1 meter below the pump inlet on the engine.



Position the radiator and fittings in such a way as to avoid any accidental contact with hot parts of the engine, such as the exhaust system, which could alter its integrity.



During operation, cooling circuit components heat up to very high temperatures: avoid touching these components before the engine has cooled down for at least 30 minutes since the last start-up.



Never use the union screws between the crankcase and the gearbox or the cover to fix the radiator or the air intake. Failure to comply with this requirement releases MWfly from any obligation and liability, and causes the automatic revocation of the guarantee.

In case of placing the radiator far away from the motor, using flow and return pipes longer than 4 meters in total and made of expandable material, it may be necessary to replace the preinstalled expansion tank with a larger one. Refer to the maintenance manual to remove the original expansion tank.

### 74-24-03 Expansion Tank Sizing



If a non-original radiator is used or the cooling circuit is modified, the required capacity of the expansion tank must be recalculated and the original one replaced if necessary.

The original expansion tank, with a total capacity of 0.72 litres, is capable of adequately compensating for a cooling system with a maximum total capacity of 5.8 liters, assuming that a cooling fluid composed of 33% ethylene glycol and 67% water

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is used and for maximum temperature jumps of 105°C: this value must also include the capacity of the radiator and fittings of the passenger compartment heating system, if the total capacity of the system exceeds this value, an increase of 0.15 litres in the volume of the expansion tank must be considered for each additional liter of cooling fluid.

In any case, it is necessary to perform the coolant system verification.

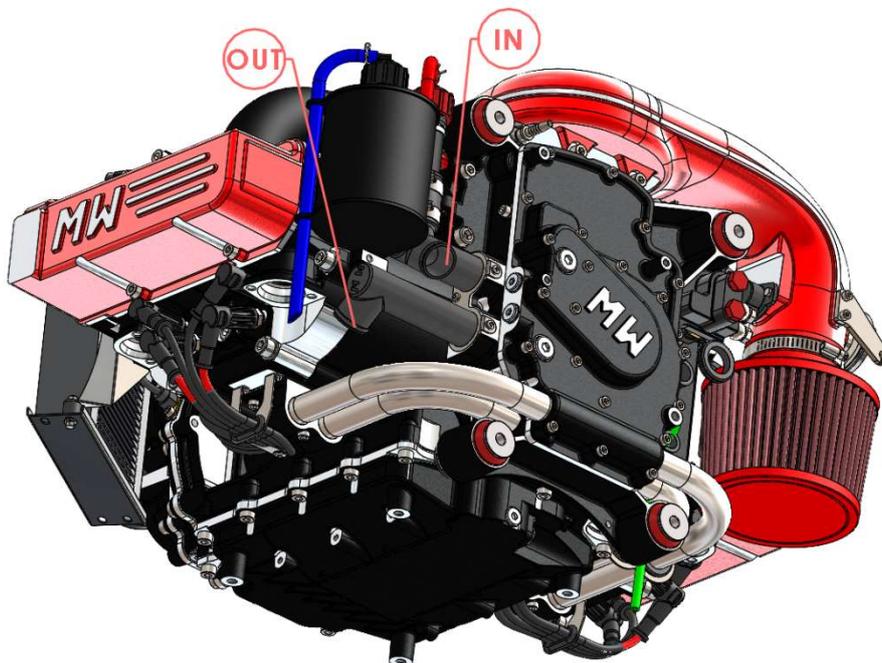
#### 74-24-04 *Circuit Implementation*



**Take the utmost care in running the hoses away from heat sources or sharp or abrasive surfaces: if this is not possible, it is necessary to protect the hoses against radiation or contact with suitable material.**

The cooling system should connect the inlet manifold and the outlet manifold of the water pump located at the rear of the engine to the radiator.

As evidenced by the labels located on the rear engine cover, the outlet manifold from the pump is the lower one, the inlet manifold to the pump is the upper one; respectively, these manifolds should be connected to the upper radiator port and the lower one. The lower manifold, if necessary, can be rotated: to facilitate rotation, loosen the three clamping screws on the manifold retaining ring; the torque should be reset to 4Nm.



75-04-P

The pipes in the system must be secured, to prevent them from being subjected to mechanical stresses with vibration or from touching sharp or hot surfaces. In the case of circuits with particularly long runs, give preference to rigid pipes (aluminum) with hemming to prevent the fittings from coming loose.

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The circuit should be made in such a way that the vent plug on the engine is above each pipe: also, loops, which could accumulate air bubbles, should be avoided. No expansion tank, thermostat, or pressure relief valve need be provided in the system: these components are already present on the engine. The expansion tank on the engine has a cap with an outlet tube for "overflow": this tube runs to the bottom of the engine.

- a.** Check that the pipe is not crushed or clogged
- b.** Ensure that the excess liquid as it exits the hose does not foul areas vital to the safety of the airplane. If necessary, plan to extend it: use only original hoses or hoses resistant to operating temperatures of 120 °C and inert to ethylene glycol



Do not interchange the two caps on the cooling system fill pipe (red and with 1-bar valve) and the expansion tank (black and without valve) with each other.

All components of the cooling system must ensure safe and stable use of the system.

The dimensions and arrangements of the system components must allow operating temperatures of the engine within limits: give preference to tubes of large cross-section, with wide radius bends and without large variations in cross-section; use new radiators with tube bundles of adequate cross-section, preferably with horizontal flow.

### 75-25-00 Recommended Cooling Fluid

Use only ethylene glycol-based coolants, preferably sold already prepared in solution with water and not in concentrated form. Preferably use liquids with organic additives (called OATs) based on phosphate, boron or silica salts, usually coloured red or orange; glycol with inorganic inhibitors (called IATs), usually coloured blue or green, or glycol with hybrid additives (called HOATs), usually coloured yellow, can also be used.



Avoid mixing glycol with inorganic additives with glycol with organic additives: in such a case, there is a risk of gelatinous intrusion into the cooling circuit, which can significantly alter the flow characteristics of the system.

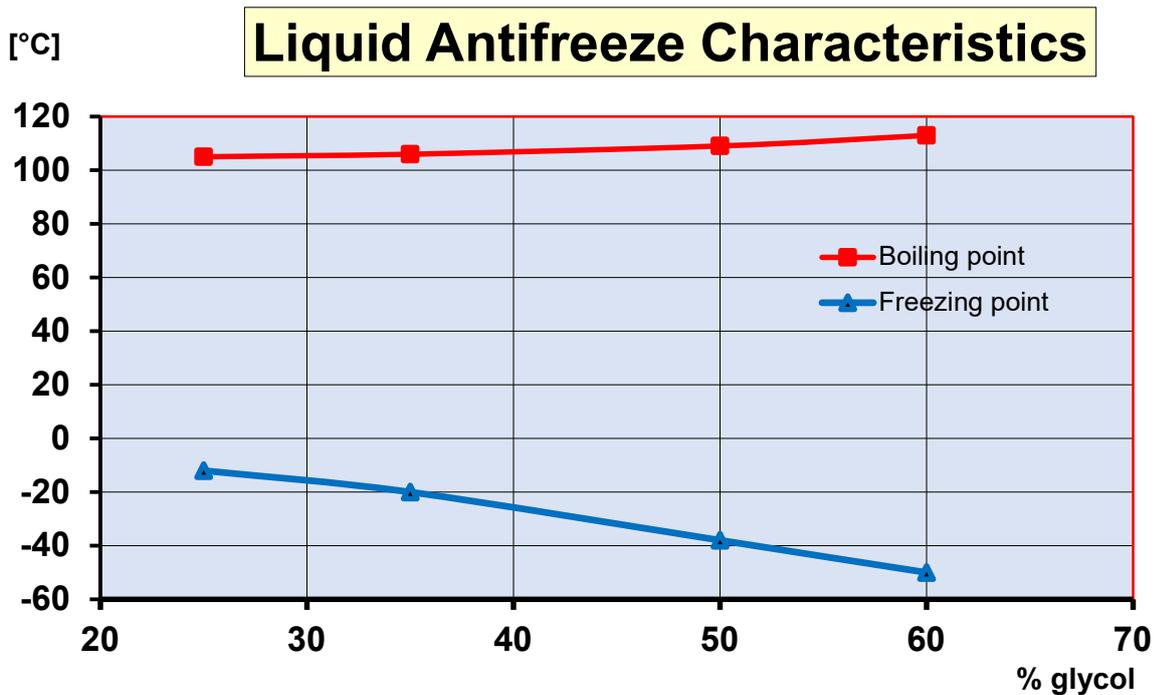


In order to switch from glycol with organic-type additives to glycol with inorganic-type additives and vice versa, it is necessary to flush the cooling system with water several times to completely remove residues of the glycol to be replaced.



Glycol with hybrid additives is compatible with both other types: in case of doubt about the type of glycol used, for any topping up use a glycol with hybrid additives (HOAT).

The typical proportion of coolant to water is one-part glycol to two parts water (33/67). In particularly cold climates, the proportion of glycol may be increased to improve freeze protection in accordance with the following diagram.



75-02-C



The use of antifreeze liquids other than ethylene glycol is not allowed. In particular, the use of propylene glycol, which subjects the thruster to higher than standard operating temperatures by having lower heat capacity, is prohibited.



The use of ethylene glycol undiluted with water is to be avoided, as it is flammable. The use of water, without the addition of antifreeze is allowed in emergencies and for short periods, as it can cause corrosion phenomena to the cooling system components and the powerplant itself.



A coolant consisting of 50% ethylene glycol and 50% water comes to a boil at a temperature of about 116 °C at a pressure of 1 bar. For this reason, the maximum operating temperature is cautiously set at 102 °C.

The data shown refers to a cooling system in full efficiency, with original vent plug and valve in perfect condition. If the installation involves operating temperatures close to the maximum attainable, it is important to frequently check the state of efficiency of the pressurized circuit.

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Keeping an eye on the coolant temperature at the inlet of the two banks is important to prevent detonation phenomena in the combustion chamber. However, it is essential to design the cooling circuit in such a way that it can ensure adequate cooling of the engine under all flight conditions away from the boiling point of the liquid, so as to avert the onset of overheating.



**It is not permissible to operate the powerplant at temperatures higher than the maximum allowed: this causes serious damage to the head gasket and can cause the powerplant to seize.**

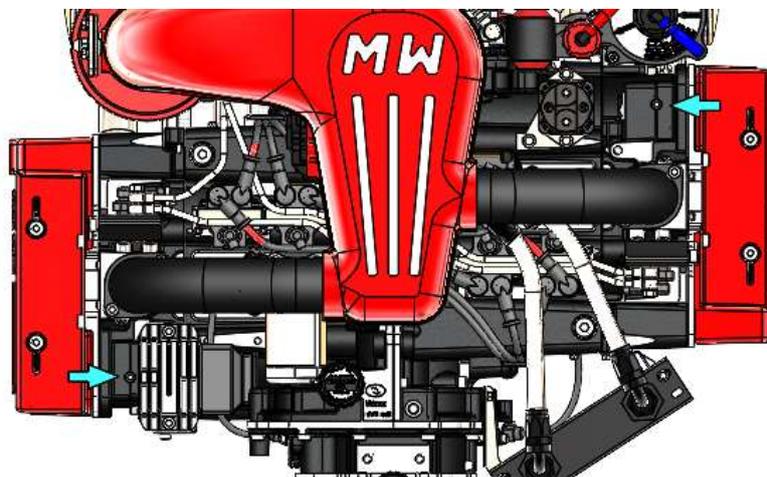
## 75-26-00 Filling the Coolant Circuit

### Necessary Materials

1. Torque wrench
2. 5 mm Allen wrench

### 75-26-01 *Filling*

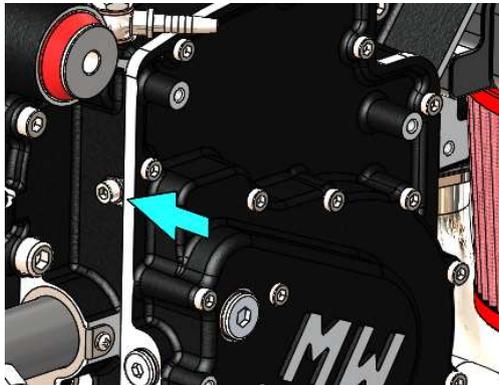
- a.** Slowly introduce liquid through the hole in the filling tube (red cap), until it flows from the two vent caps highlighted in the figure, previously removed [2].



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- b.** Reinstall [2] the two circuit vent screws located on the heads, without tightening them.
- c.** Unscrew [2] the liquid pump vent screw located on the left side of the rear cover, partially hidden by the filling tube.

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- d.** Add liquid to the filling tube until the liquid itself comes out of the pump vent screw and the tested vent screws (remained partially unscrewed).
- e.** If the system is equipped with a passenger compartment heating radiator, unscrew any vent hole on the same until the liquid comes out of the vent screw.
- f.** Fill the filler tube (with red cap) to the brim and the expansion tank (with black cap) 2/3 of the way up.
- g.** Tighten [1+2], in order, the pump bleed screw, the bleed screws on the heads and any bleed screw on the heating radiator to the prescribed torque.
- h.** Add coolant to the filler tube up to the brim and hand-tighten both circuit plugs.



If the system consists, even only partially, of rubber material pipes, it is advisable to "pump" the pipes, so as to induce any air bubbles present to exit in the direction of the filling pipe.

#### 75-26-02 Vent

After initial start-up, it is necessary to bleed the cooling system to eliminate any residual air bubbles; operate according to the procedure described below.

- a.** Loosen [2] the vent caps on the heads to eliminate the air accumulated in the cooling circuit; close them again when the liquid gushes out or when the venting is complete.



When carrying out the bleeding operations, be sure to take the utmost caution to avoid burns or burns caused by contact with the coolant.

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- b.** Partially open [2] the water pump vent screw: close it again when the liquid gushes out or when the venting is complete.
- c.** Partially open any vent screw on the passenger compartment heating radiator: close it again when the liquid gushes out or when the venting is complete.
- d.** Partially open the filler cap until you see the liquid coming out of the filler pipe: if you do not see the coolant flowing out, open the filler cap completely; if you see liquid gushing out, tighten it by hand.
- e.** Wait about 15 minutes for the engine and operating fluid to cool down, and then open the filler cap to top up the cooling circuit. If no liquid leaks from the breather plugs on the cylinder heads when the engine is hot, unscrew them [2] and then top up from the filler pipe.
- f.** If necessary, also top up the expansion tank.
- g.** Tighten [1+2] to the prescribed torque (6 Nm) the breather plugs on the cylinder heads.
- h.** Tighten [1+2] to the prescribed torque (6 Nm) the breather screw on the cooling pump and any screw on the passenger compartment heating radiator.
- i.** Restart the engine and repeat the operations described above after keeping it at about 2500 rpm for about 5 minutes.
- j.** Stop the engine and check for coolant leaks, especially at the radiator and pump connections. If necessary, bleed the system again, repeating the procedure from step **a** to step **i**.
- k.** Use the engine normally. After use, wait for the coolant to cool completely and check the level inside the filler pipe and expansion tank: if necessary, bleed the system again.
- l.** Continue testing after flying until no more filling of the fill tube is required (usually after one or two flights, depending on the system).



**Flying before venting the cooling system is extremely dangerous as it can cause the engine to overheat, suddenly and unexpectedly, and cause damage to it and possible seizure.**



If the level in the filling pipe is constantly low, it is necessary to bleed the system again, after having carefully checked the absence of leaks from the circuit.



Before each flight, check and if necessary top up the level in the expansion tank: a level that is too low can cause the presence of air bubbles inside the cooling circuit, with consequent overheating.

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## 75-27-00 Verificaton and Validation



As a passive safety element, the installer should provide warnings and inspection ports that induce checking of the coolant level and the condition of the cooling system piping.



A label with before flight checks to be made and specifications for the cooling fluid is placed on the expansion tank.

Set-up operations of the cooling system should be carried out at first on the ground, so as to avoid an emergency in case there are nonconforming parameters or situations. Only after reaching a certain degree of functional safety of the system should test flights be carried out, for verification of parameters under operating conditions.

Fine-tuning is mainly concerned with the sizing of the cooling air intake and the subsequent verification, through temperature measurement, of compliance with the operational limits of the system. Another aspect concerns the verification of tightening and the presence of any "hot spots" in the circuit.

### 75-27-01 *Air Intake Sizing*

It is not possible to provide standard data for sizing the cooling air intake, since, as the position on the engine cowl, speed and attitude of the aircraft vary, the amount of air actually passing through the radiator can also vary considerably.

Some sizing criteria are valid for most applications, however, and are summarized below.

- The air intake should be placed as close as possible to the plane of rotation of the propeller.
- It is convenient that the height and width dimension of the air intake is about 80% of that of the radiator.
- The most efficient location of the air intake is usually in the lower part of the cowling.
- If you must place the air intake on one side of the engine cowling, it is best to choose the right side for right-turning engines, and vice versa.
- Make an aluminum sheet metal or fiberglass conveyor between the radiator and the air intake on the engine cowling in such a way as to ensure a fresh and quick supply of air to the radiator. If necessary, the M8x1.25 threaded holes in the underside of the oil pan can be used to attach the air conveyor.
- To improve the efficiency of the radiator, any gaps that may be present between the air intake, conveyor and the radiator itself should be sealed.
- The total area of the air extraction window from the cowling should be at least three times larger than the sum of all air intakes on the cowling, whether cooling, supply or ventilation.
- It is convenient to conform the brim of the extraction window to resemble a spoiler, to deflect air lapping the cowling and create a vacuum zone.
- Avoid placing the exhaust or parts of it in front of the radiator.

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### 75-27-02 *Cooling Fluid Temperature Measurement*

There are two liquid temperature sensor arrangements on the engine, located at the liquid inlet in each cylinder head, with M12x1.5 threads and two others with M10x1 threads at the top of each bank.

During test flights, it is necessary to simultaneously verify the two temperatures, which should not differ by more than 5 °C, and in any case be lower than the maximum allowable temperature under any operating condition. However, the typical operating temperature may vary by a few degrees depending on the installation, i.e., the location and size of the radiator, the cross section of the pipes, the amount of bends and fittings in the circuit, and the size and aerodynamic efficiency of the air intake for the radiator.

In case of doubt, dissimilarity of data readings, or particularly complicated circuits, it may be advantageous to use a third and a fourth temperature sensor, placed near the liquid inlet and outlet from the radiator: in this way it is easy to understand what the thermal jump is and thus the effectiveness of the radiator under various flight conditions. In any case, the additional sensors are to be considered for the sole purpose of tuning the system.

In case of the presence of vapor bubbles in the cooling circuit, the reading of the sensors may be distorted, giving incorrect indications of the actual thermal state of the engine, either in excess or in defect of the if real value. To avoid this possibility, before taking the sensor reading and using the engine in flight, it is essential to perform the procedure of purge the circuit of cooling system.

### 75-27-03 *Relation between Ambient Temperature and Engine Temperature*

It is desirable to perform system tuning under the environmental conditions considered "limit" for aircraft operation. The most severe flight conditions for cooling purposes are obtained by operating as summarized below.

- Maximum ambient operating temperature
- Maximum power applied for maximum allowable time
- Lowest flight speed in relation to applied power

In the case where tests are carried out at ambient temperature below the maximum temperature considered permissible, the refrigerant temperature rise can be calculated from the change in ambient temperature according to the following relation:

$$\Delta T_{h2o} = \Delta T_{amb}$$

This means that each degree increase in ambient temperature produces one degree increase in refrigerant temperature. For example, running the tests at an ambient temperature of 20 °C, and measuring a maximum refrigerant temperature of 90 °C, we can consider that at an ambient temperature of 35 °C, the refrigerant temperature would rise by about 15 °C, reaching 105 °C.

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This relation can be applied only from refrigerant temperatures above the maximum thermostat opening temperature. In fact, below that threshold, the efficiency of the radiator is reduced by the thermostat.



However, the maximum temperature achievable under limiting ambient temperature conditions must be verified in reality. The above report is only valid for a rough sizing of the cooling system.

#### 75-27-04 Verification Test

To carry out the cooling system tuning, proceed as follows.

- a.** Fill and purge the system as described in the maintenance manual
- b.** Conduct ground tests for about 15 minutes with the engine warm and at various engine speeds: during these operations constantly check the cylinder head temperatures to avoid overheating. If the engine can stay at the correct temperature with a continuous speed of at least 75% of the maximum possible in flight, it is likely that the air intake is well proportioned.
- c.** Turn off the engine and inspect all hot system junction points very carefully, looking for any leaks.
- d.** Tighten any metal clamps holding the fittings until engine is hot.
- e.** With the engine cold, look for any overheating or rubbing points on the pipes; if necessary, make changes to the system.
- f.** When the engine is cold, check the amount of refrigerant fluid inside the expansion tank: if the level is at a minimum (below 20% of total capacity), it is likely that there are leaks in the system or, if the total fluid capacity in the system has changed, that the capacity of the tank itself is inadequate.
- g.** Repeat the above steps until the abnormalities are solved.
- h.** Take the aircraft into the air to check operating conditions, especially during take-off, keeping close to the runway so that emergency landings can be made in case of engine overheating or circuit failure.
- i.** When the engine is cold, recheck the amount of liquid inside the expansion tank to avoid the formation of air bubbles in the cooling circuit.

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## 76-00-00 ENGINE CONTROLS

### 76-01-00 Injection and Ignition Module (IJ-m)

Each engine is delivered with the engine harness and the control unit group (hereinafter referred to as IJ-m) wired and tested.



**All the branches of the harness are attached to the engine to prevent damage from vibration: if the wiring or any part of it is removed it is necessary to reassemble in exactly the same position so as not to affect safety.**

The part of wiring necessary for connection to the instrument panel or to the on-board devices must be made by the installer, following the instructions given in this chapter.

The electrical component installations to be carried out are as follows.

- a.** IJ-m control unit module
- b.** Battery
- c.** System ignition key switch
- d.** Main injection shutdown switch (kill switch A)
- e.** Auxiliary injection shutdown switch (kill switch B)
- f.** Start button
- g.** Control unit diagnosis warning light A (not necessary when mounting the EM-m instrument)
- h.** Control unit diagnosis warning light B (not necessary when mounting the EM-m instrument)
- i.** Auxiliary pump switch
- j.** FD-m pump unit: alternatively, main fuel pump and auxiliary fuel pump
- k.** Cockpit brakers

All other components are included in the IJ-m.

An aircraft electrical system built according to a standard scheme guarantees very high safety criteria, as specified below.

- The two ECUs normally operate together and are supervised by the EM-m module which can export the data in the CAN AEROSPACE line and detects any anomalies in the system.
- An auxiliary battery (optional) can be connected to the system from the key switch as an alternative to the main battery, in case of failure of the main battery.
- The capacitor integrated in the IJ-m allows the engine to operate without problems over 1500 rpm and in case of the failure of both batteries since it stabilizes the current produced by the generator.
- The auxiliary fuel pump allows an increase in the safety of the fuel system in critical stages for the flight (take off and landing).

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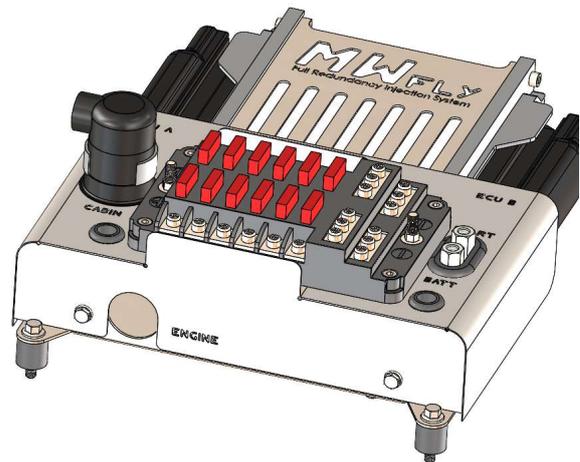
- The fuses pre-installed in the IJ-m, as well as the cabin breakers provided in the diagram, guarantee total protection of the electrical components, allowing the motor to operate with any limitations even in the presence of partial short circuits of the system or its components.

### 76-01-01 Description

The injection system is kind of semi-phased and uses one injector per cylinder bank; the injection times are calculated on the basis of the power demand (RPM and THROTTLE position) and corrected on the basis on barometric pressure (altitude) and the oil temperature. Furthermore, the injection system also manages the idle and warm up phase conditions of the engine by implementing appropriate injection and ignition control strategies.

The ignition system is inductive discharge and lost spark and controls the advance as a function of rpm and THROTTLE position; this advance value is then corrected as a function of other parameters (intake air temperature and battery voltage), to adapt it to the state of operation of the engine. The engine rpm and the phase are detected by two magnetic captors (one for each ECU), working in parallel, reading the passage of teeth arranged on the fly wheel, fixed directly to the engine crankshaft.

The rpm sensors supply the signal independently, therefore each to a single injection control unit. Each injection control unit is equipped with an output for the diagnostic light, which signals the presence of any system anomalies



76-01-P

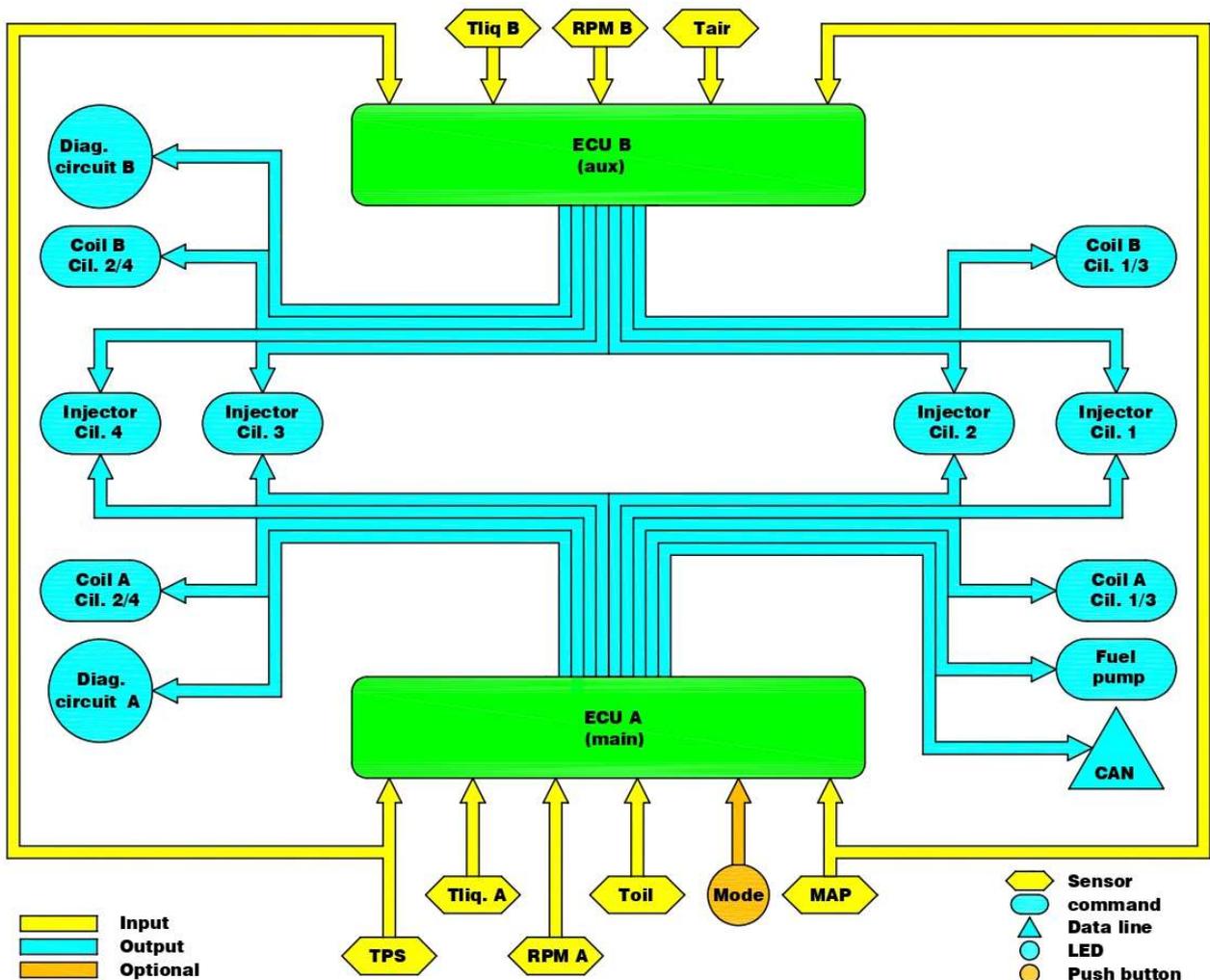


**In the event that, during the flight, one of the two diagnostic lights come on, it is essential to land as soon as possible, even if the engine apparently does not show any problems.**

The injection and ignition phases are normally controlled by both control units; however, the engine, in the event of a failure of one of the two control units, can also operate without limitations with the remaining control unit, both in the event that the failure concerns the main control unit, both auxiliary control unit. The passage from the standard operating mode with both control units to the emergency mode with a single control unit can take place at any speed and without interruptions in the power supply. With the control unit B, the idle speed is automatically increased by the injection system to about 1700 rpm, to prevent the involuntary shutdown of the engine in the event of battery disconnection. In this circumstance, the emergency

manoeuvre involves switching off the control unit A, to prevent the engine, powered by the generator alone, from accidentally switching off below 1500 rpm.

The following figure shows the functional diagram of the injection system.



76-01-C

Each control unit controls the main fuel pump, which is operated for about 3 seconds when the ignition system is turned on in order to pressurize the fuel system; if the engine does not start the pump turns off, and then it will be switched on as soon as the engine starts; if the engine is shutdown of the engine, even accidentally, the fuel pump is immediately turned off so as to stop sending fuel to the engine. The auxiliary fuel pump, in parallel to the main pump, which will be switched on, for safety reasons, in critical conditions of flight (take off and landing)

The injection system is equipped with a data communication CAN line, that can send all the parameters acquired from both control units to a digital instrument (i.e. EFIS, EMS), without adding other sensors.

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If it is necessary to carry out welding operations on the aircraft, it is essential to disconnect the main connector from the injection control unit, to avoid irreparable damage.



The electrical wiring is made of high-quality material: however, care must be taken in the maintenance, cleaning and washing of the engine.



The advantages offered by injection fuelling, instead of traditional carburettors, are many: there is an improvement in power delivery, consumption, regularity of operation, in the emission of polluting compounds and in weight.



The injection control unit is equipped with a diagnostic function: anomalies or operating conditions that are potentially harmful to the integrity of the engine are recorded in non-labile memory



If the electrical system is built following the diagram provided in this manual, the engine can operate indefinitely at speeds above 1500 rpm even without the battery connected to the electrical system, having previously turned off all other electrical utilities.



The adoption of two rpm sensors is due to redundancy criteria aimed at minimizing the consequences of a possible failure on these components, that are the only truly critical sensors in modern injection systems, together with petrol pumps (which are also double)



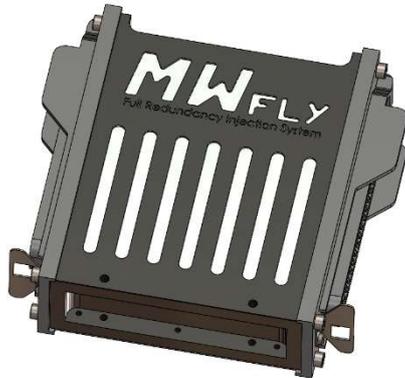
In the event of failure of any sensor other than the rpm sensor (foreseen double), each of the two control units activates the limp home mode, which allows the engine to continue to operate without particular limitations. However, in this mode, starting the engine from cold is very difficult. The limp-home mode is indicated by the lighting of the diagnostic lamp.

All the components listed and described below are pre-assembled inside the injection and ignition unit and therefore no action must be performed on them: the description is provided in order to better understand the functions of the system

## 76-02-00 Components Features

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### 76-02-01 Injection and Ignition Control Units



76-02-P

- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>▪ Dimension ECU's case</li> <li>▪ Dimension IJ-m</li> <li>▪ Weight IJ-m</li> <li>▪ Case protection</li> <li>▪ Power supply</li> <li>▪ Maximum absorbed current</li> <li>▪ Ignition control</li> <li>▪ Injection control</li> <li>▪ Type of strategy</li> <li>▪ Correction on spark advance</li> <li>▪ Correction on fuel injection time</li> <li>▪ Additional/optional function</li> <li>▪ Max temperature without power supply</li> <li>▪ Max temperature in flight</li> <li>▪ Minimum temperature in flight</li> <li>▪ Typical temperature in flight</li> </ul> | 101x83x29 mm<br>260x230x100 mm<br>2600 g<br>IP 64<br>7÷17 V<br>2 A<br>mapped, lost spark, and inductive discharge<br>Mapped semi phased low impedance injector<br>alfa-n (throttle position-rpm)<br>air temperature, battery voltage<br>oil temperature, air temperature, phase, battery voltage<br>diagnosis, self-mapping, limp-home<br>95 °C<br>80 °C<br>-20 °C<br>35 °C |
|--|---|

### 76-02-02 Capacitor

The capacitor regulates the input current to the control unit group, and allows it to work even with the battery disconnected from the electrical system.



76-03-P

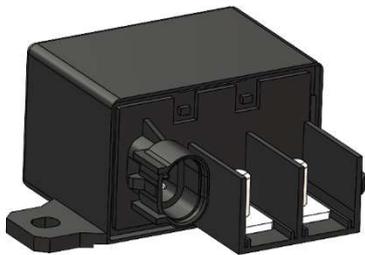
- Type electrolytic

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- |                         |                           |
|-------------------------|---------------------------|
| ▪ Capacitance           | 22000 µF                  |
| ▪ Voltage               | 25 V                      |
| ▪ Operating temperature | -40÷105 °C                |
| ▪ Weight                | 75 g                      |
| ▪ Connection            | 2 for D5 mm ring terminal |
| ▪ Tightening torque     | 2 Nm                      |

### 76-02-03 Master Relay

The master relay acts as a general switch, controlled by an adequate key switch installed in the cabin. The characteristics of this component are as follows.



76-04-P

- |                                |                             |
|--------------------------------|-----------------------------|
| ▪ Type                         | ON÷OFF                      |
| ▪ Switch voltage               | 12 V                        |
| ▪ Absorption of excitation     | 4 W continuous              |
| ▪ Continuous switching current | 130 A                       |
| ▪ Peak switching current       | 300 A                       |
| ▪ Vibration resistance         | 5 G vertical and horizontal |
| ▪ Number of cycle              | >5x10 <sup>4</sup>          |
| ▪ Operating temperature        | -40÷85 °C                   |
| ▪ weight                       | 220 g                       |
| ▪ Pole terminal                | 2xscrew ring terminal D6 mm |
| ▪ Torque on pole terminal      | 5 Nm                        |
| ▪ Excitation terminal          | connector SS 2 ways         |
| ▪ Fixing point                 | wheelbase 84 mm screw M6    |

To ensure engine operation even with the battery disconnected from the circuit or in failure, it is necessary to faithfully reproduce the diagram shown.

### 76-02-04 Main Fuel Pump Relay

The main fuel pump relay is controlled by the ECUs according to the safety strategy: the pump will be operated for about three seconds to pressurize the fuel system when the ECUs are switched on, and then the fuel pump will be automatically switch off; when the engine starts the pump will be switch on; when the engine stops the pump will stop.

The main fuel pump has the following characteristics.

- |                         |        |
|-------------------------|--------|
| ▪ Type                  | ON÷OFF |
| ▪ Switching voltage     | 12 V   |
| ▪ Max switching current | 25 A   |

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- Cycle >100.000
- Operating temperature -40÷125 °C
- Weight 18 g
- Coil terminal 2 male faston 4.8 mm
- Pole terminal 2 male per faston 4.8 mm

### 76-02-05 Amperometric Shunt

The amperometric shunt measures the current flow between the battery and the electrical system of the aircraft: if the flow is positive the battery is recharged by the generator, if the flow is negative the battery supplies current to the electrical system.



It is normal that with the engine at idle or with two fuel pumps on, the current flow is negative.



76-05-P

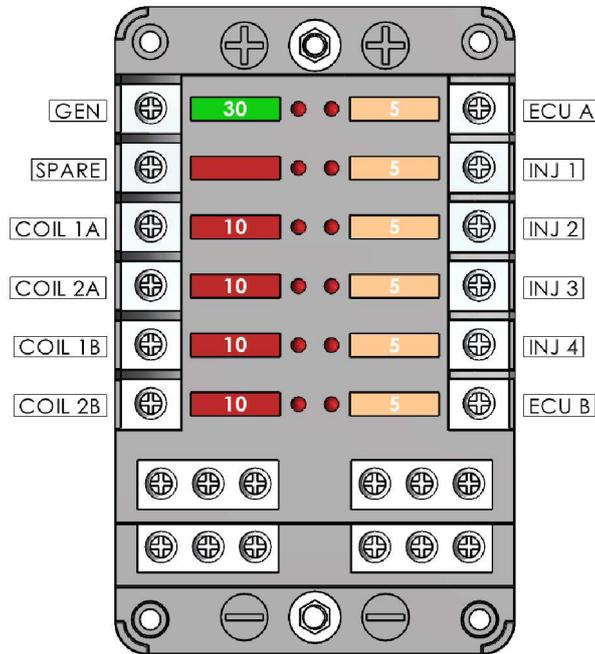
- Type Lamellar
- Max current 100 A
- Voltage at 100 A 100 Mv
- Accuracy ± 0,25 %
- Terminal for current flow D 6mm
- Terminal for current measure D 4 mm

### 76-02-06 Fuse Box

The fuse box is located outside the control unit group: the box itself is protected by a transparent cover that can be easily removed by acting on the fixing clips on the sides. The fuses housed in the box protect the ignition and injection system, allowing, in the event of an overload of one of the protected components, all the others to continue operating. A led located near each fuse lights up in the event of its interruption, simplifying troubleshooting.

The following figure shows the value of each fuse and the attribution to the component it protects, the meaning of which is as follows.

- |                                      |                                |
|--------------------------------------|--------------------------------|
| GEN = generator                      | ECU A = control unit circuit A |
| SPARE = not connected                | INJ 1 = injector #1            |
| COIL 1A = coil #1 ignition circuit A | INJ 2 = injector #2            |
| COIL 2A = coil #2 ignition circuit A | INJ 3 = injector #3            |
| COIL 1B = coil #1 ignition circuit B | INJ 4 = injector #4            |
| COIL 2B = coil #2 ignition circuit B | ECU B = control unit circuit B |



76-06-P

- |                       |          |
|-----------------------|----------|
| ▪ Fuses type          | Lamellar |
| ▪ Number of positions | 12       |
| ▪ Contact width       | 5,2 mm   |
| ▪ Max voltage         | 32 V     |

## 76-03-00 Components Required for the Electrical System

### 76-03-01 Battery

- |                 |         |       |
|-----------------|---------|-------|
| ▪ Capacity      | min     | 12 Ah |
|                 | typical | 16 Ah |
| ▪ Peack corrent | min     | 100 A |
|                 | max     | 300 A |

It is recommended to use solid dielectric (gel), maintenance free batteries.



The minimum recommended capacity is that which guarantees an operating autonomy of the engine of at least 10 minutes (with all accessory utilities off), in case of generator failure and with the battery in perfect working order.



The battery must be installed as close as possible to the engine, using cables of adequate section and high-quality crimping: otherwise the performance of the starter and generator could be significantly reduced.

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### 76-03-02 Master Switch

The main switch of power plant, to be installed in the cabin, is used to energize the master relay. This switch may be a type key or toggle switch.

The minimum characteristics of the switch must be the following.

- |                               |                |
|-------------------------------|----------------|
| ▪ Switch operation            | Off, 1, 2, 1+2 |
| ▪ Contact voltage DC          | 12 V           |
| ▪ Contact current             | 3 A            |
| ▪ Panel hole dimension        | D16 mm         |
| ▪ Switch terminals            | screws         |
| ▪ Number of cycles            | >10.000        |
| ▪ Operating temperature range | -30÷65 °C      |

The key is removable only in OFF position



The use of a switch with a safety guard is recommended, as an involuntary actuation of the switch in flight could cause an unwanted shutdown of the engine.

### 76-03-03 Toggle Switch

For the ECUs and for the auxiliary fuel pump, use a toggle switch with the following characteristics.

- |                    |               |
|--------------------|---------------|
| ▪ Switch operation | ON÷ON, S DPDT |
| ▪ Contact voltage  | 12 V          |
| ▪ Contact current  | 15 A          |
| ▪ Switch terminals | Screws D5 mm  |
| ▪ Number of cycles | >10.000       |

The connections of the two poles are identical (parallel connection): the adoption of the double pole improves passive safety installation.



The use of a switch with a safety guard is recommended, as an involuntary actuation of the switch in flight could cause an unwanted shutdown of the engine.

### 76-03-04 Cabin Fuses

The fuses (preferably resettable as breakers) that according to the diagrams A-24-02-C and A-24-03-C are to be installed in the cabin, must have the following characteristics.

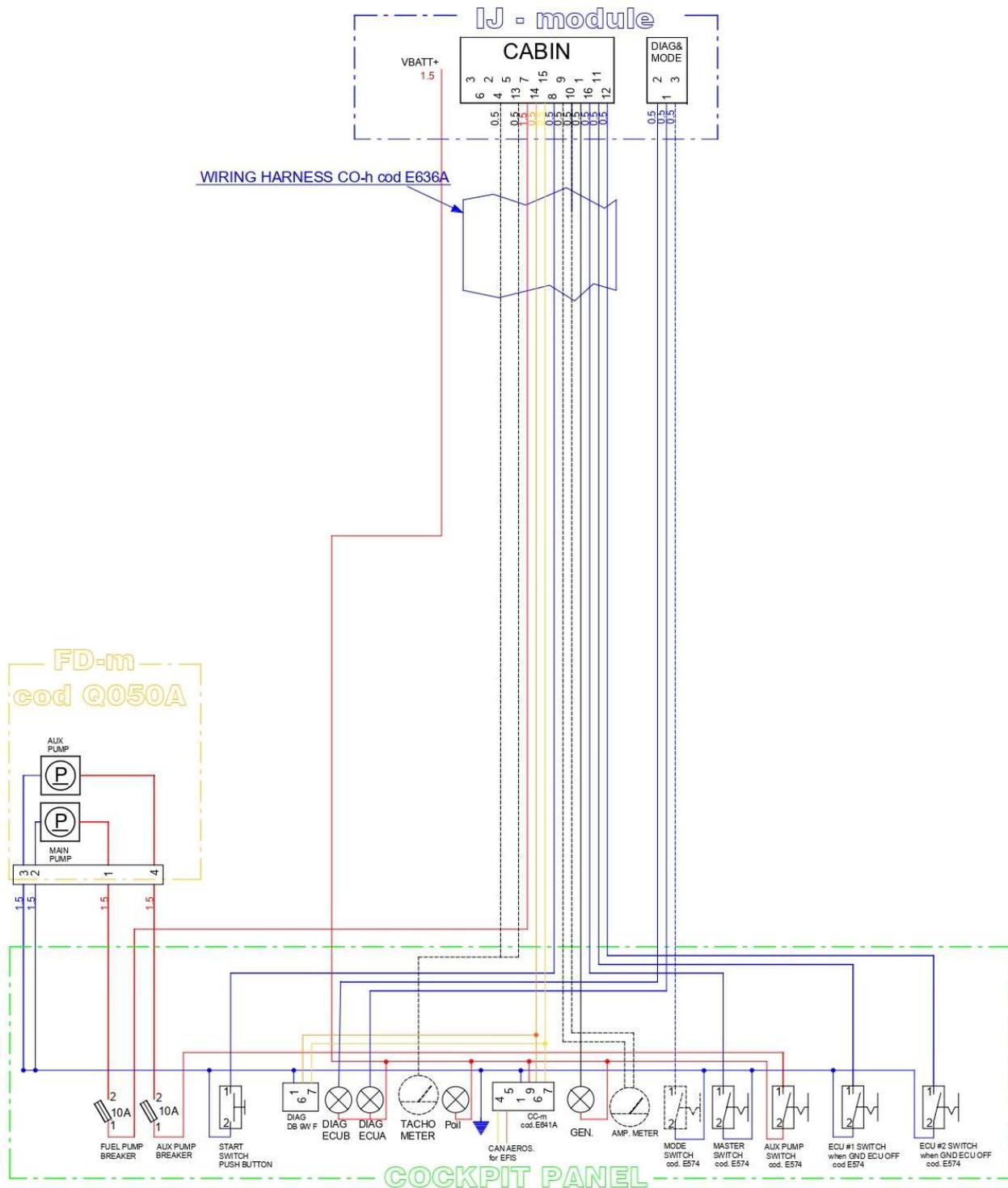
- |                               |            |           |
|-------------------------------|------------|-----------|
| ▪ Nominal voltage             |            | 12 V      |
| ▪ Contact current             | fuel pump. | 10 A      |
|                               | EM-m       | 1 A       |
|                               | Governor   | 2 A       |
| ▪ Operating temperature range |            | -20÷60 °C |

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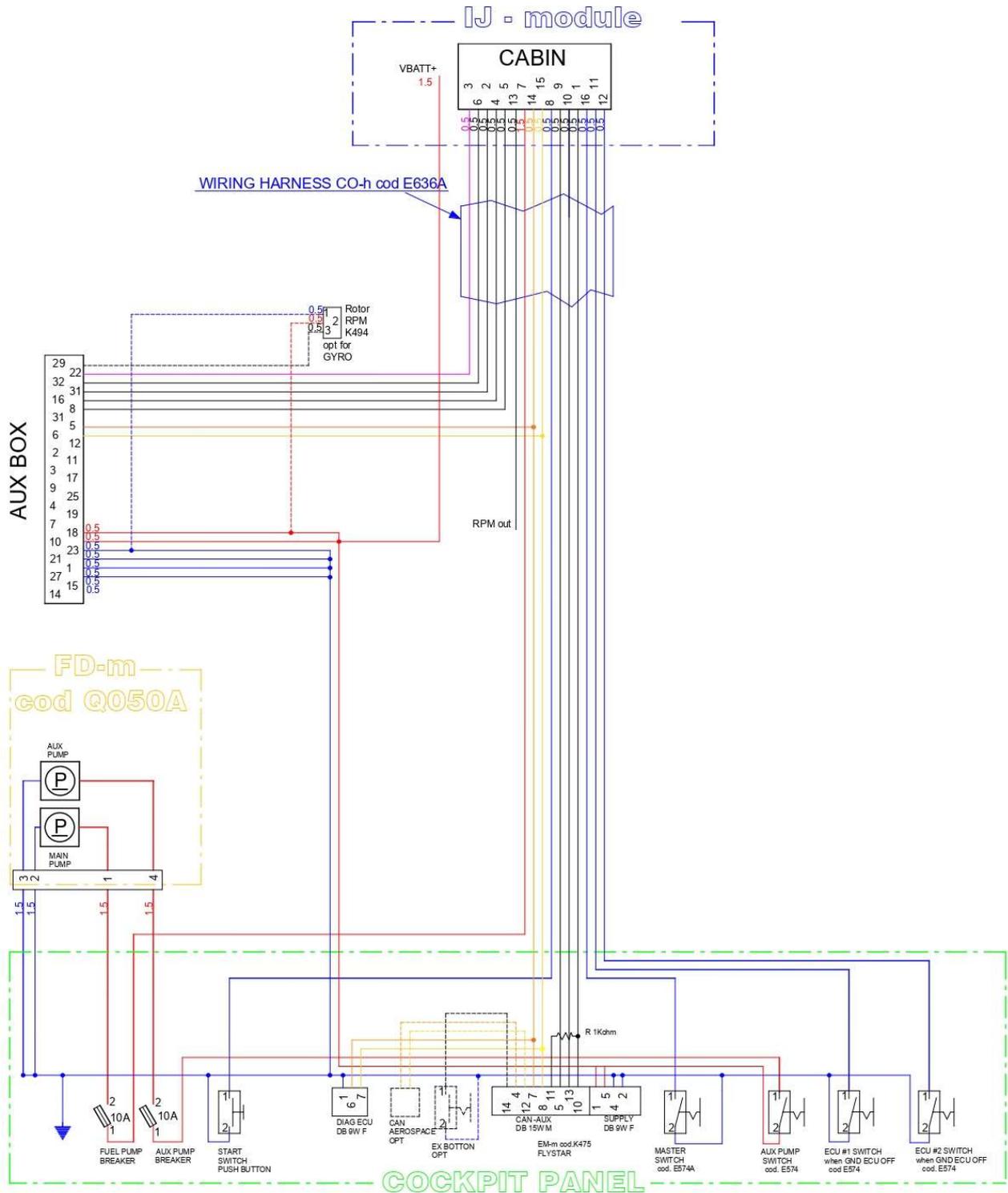
- Number of cycle >6.000

### 76-04-00 Making the Wiring

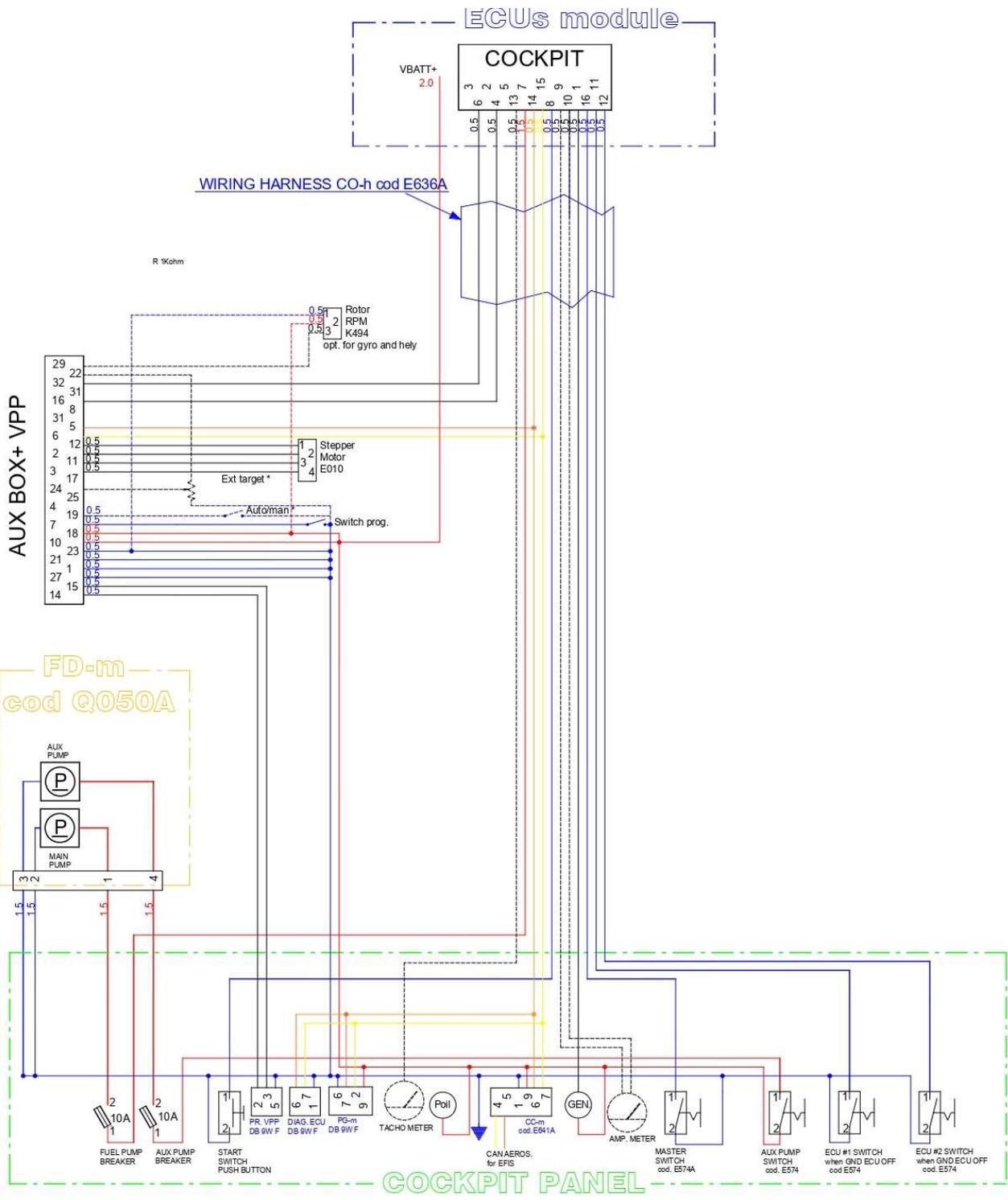
Each powertrain is delivered with the engine harness mounted and secured. The wiring part for connection to the instrument panel or to the on-board equipment must be made by the installer, following the diagram and instructions below. The diagram also indicates the fuses and breakers to be added to the system, in addition to those already included in the IJ-m.



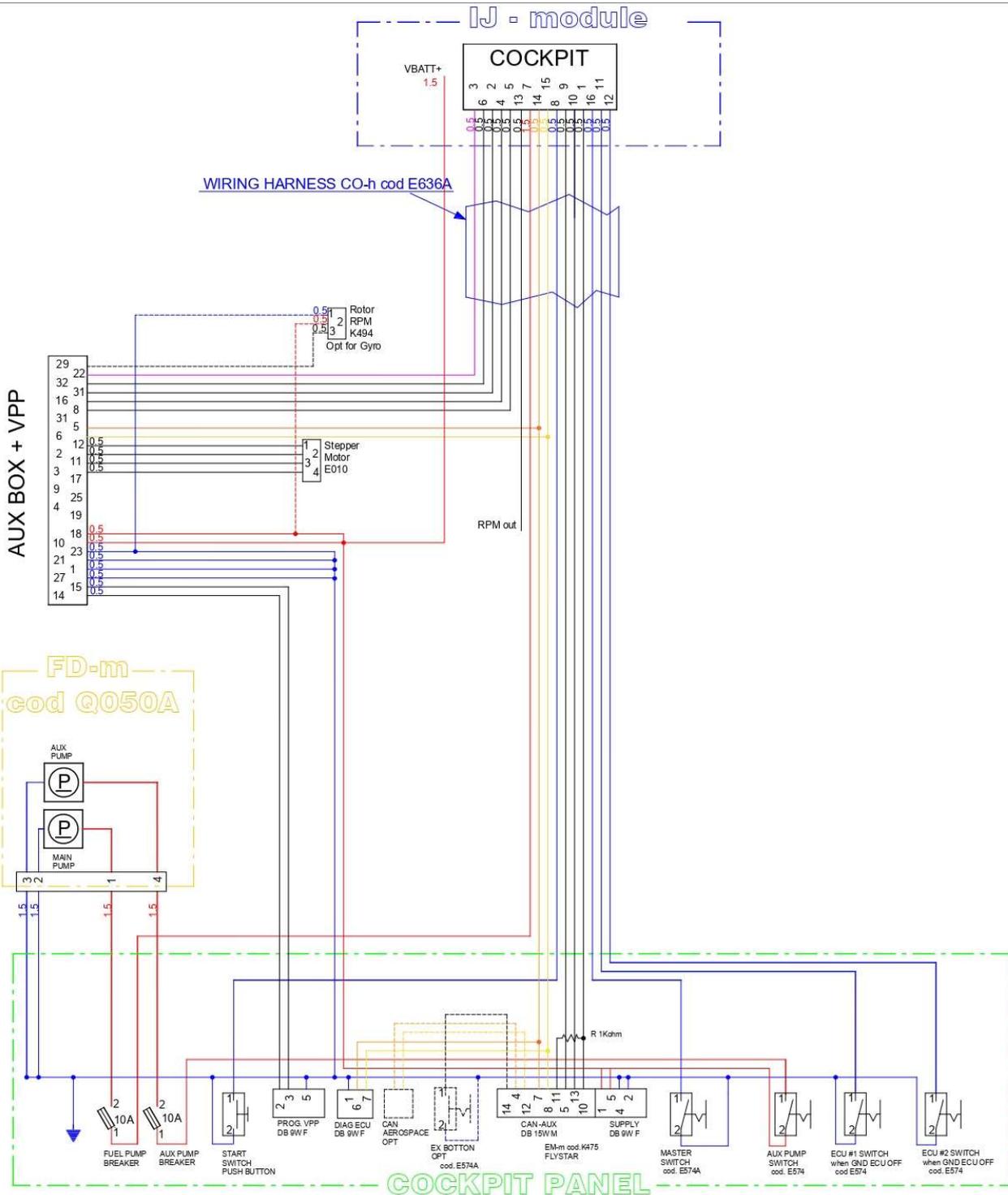
76-02-C wiring diagram with C2C V.3.7



76-03-C Wiring diagram with EM-m V3.7



76-04-C - wiring diagram with PG-m and C2C V.3.7



76-05-C – Wiring diagram with EM-m and VPP V.3.7

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La messa in opera dell'impianto elettrico deve essere eseguita da personale con competenze specifiche e preparato allo scopo: evitare l'improvvisazione.



Failure to comply, even partially, with the wiring diagram shown in figure 20-02-C or 20-03-C causes a potential risk of fire, serious damage, or unwanted shutdown of the engine, and causes the revocation of all warranty.



The installation of the electrical system must be performed by personnel with specific skills and prepared for the purpose: to avoid improvisation.

The aircraft wiring must be suitably fixed, in order to prevent excessive mechanical stresses due to vibrations, interference with the controls; avoid, in case of excessive length, to roll up the wiring on itself; also avoid passing near hot spots (exhaust system).



Most of the failures of electronic systems derive from failures in the wiring harness: it is therefore necessary to take the utmost care in installing the wiring.

Referring to diagrams 76-02-C, 76-03-C, 76-04-C and 76-05-C, make the aircraft wiring as per the following tables, each of which shows the assignment of the contacts (pin-out) to the specified connector.

<b>CABIN Connector on IJ-m (E636A Harness) V.3.7</b>			
# pin	Description	Wire dimension [mm <sup>2</sup> ]	note
1	Generator led alarm	0.5	
2	Fuel temperature sensor	0.5	Only for version with EM-m
3	VREF 5Volt	0.5	Only for version with EM-m
4	Oil pressure sensor/pressure alarm	0.5	Oil pressure sensor only for version with EM-m
5	Fuel pressure sensor	0.5	Only for version with EM-m
6	Gearbox oil temp. sensor	0.5	Only for version with EM-m
7	Vbatt main fuel pump	1.5	
8	Start relay	0.5	
9	Shunt (to master)	0.5	
10	Shunt (to load)	0.5	
11	Kill switch ECU A	0.5	
12	Kill switch ECU B	0.5	
13	RPM out signal	0.5	4 impulse for RPM

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14	CAN +	0.5	
15	CAN -	0.5	
16	Master relay	0.5	

76-06-C

<b>DIAG-ECU Connector on IJ-m (3V F lemo connector)</b>			
# pin	Description	Cable Dimension [mm <sup>2</sup> ]	note
1	Diagnosis LED ECU A	0.5	Only for version without EM-m
2	Diagnosis LED ECU B	0.5	Only for version without EM-m
3	mode Input	0.5	Only for version without EM-m

76-07-C



Connect the battery after completing and checking the entire electrical harness.

## 76-05-00 Installation and Connection of Components

### 76-05-01 Preparation of Cockpit Panel

Create the instrument panel by installing the components necessary for the engine electrical system, as shown below.

- a.** Master switch
- b.** Toggle switch ON-OFF to switch off ECU A (Kill switch 1)
- c.** Toggle switch ON-OFF to switch off ECU B (Kill switch 2)
- d.** Toggle switch ON-OFF for auxiliary fuel pump
- e.** Pushbutton for engine start (Start switch)
- f.** LED for diagnosis ECU A (version without EM-m)
- g.** LED for diagnosis ECU A (version without EM-m)

The installation of the following components is optional.

- Toggle switch (mode switch) to active the second map on ECU A
- Breaker 10 A for main fuel pump
- Breaker 10 A for aux fuel pump.

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## 76-05-02 IJ-m

Evaluate where to place the control unit group inside the aircraft or, alternatively, on the firewall: in the second case, consider that the control unit group must not be exposed to any splashes of water, nor to the heat from the exhaust system.

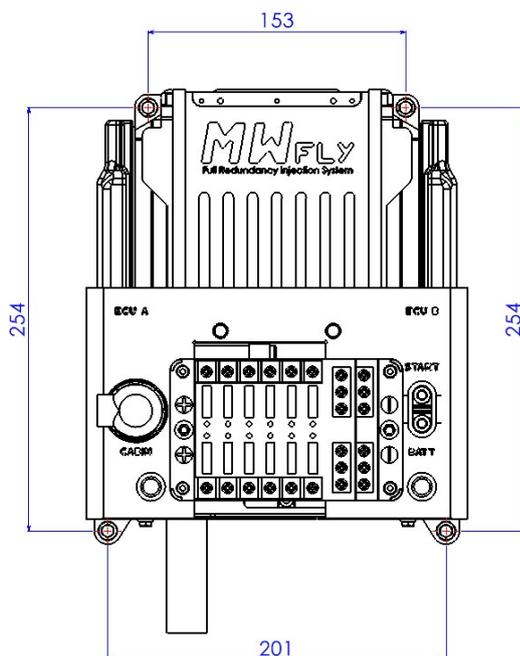
It is important to maintain the accessibility necessary to check or eventually replace the fuses and to easily remove the upper connector, called "Cabin".

Also consider where to fix the flying connector with flanging and nut, called "Engine", which comes out from the lower side of the IJ-m to the firewall: check that this position does not correspond, in the engine compartment, to particularly hot points (proximity of the muffler), to avoid subjecting the counterpart connector to excessive heat.



Give preference to a horizontal position installation of the IJ-m.

- a. Drill four holes on the flame arrester with a 5.5mm bit, respecting the measurements shown in the following figure.

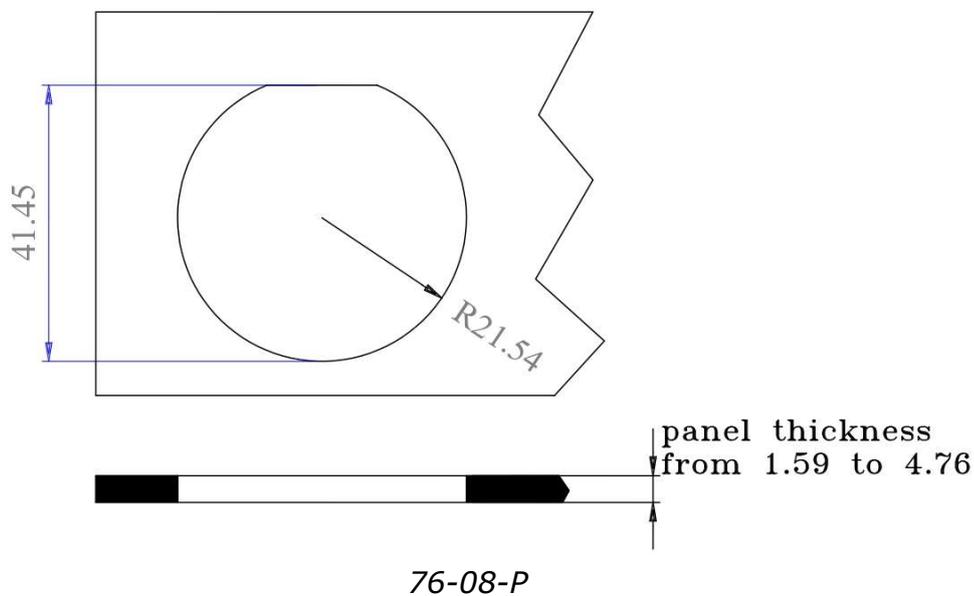


76-07-P

- b. Secure the control unit group by tightening the 4 M5 nuts to a torque of 5Nm. In case of difficulty in accessing the rear part of the selected support surface, it is possible to use it to fix the threaded inserts: in this case it is necessary to unscrew the 4 anti-vibration mounts from the control unit group, screw them to the chosen support surface using the stem, then screw the control unit group to the 4 anti-vibration mounts.

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- c. In the case the IJ group is installed inside the cabin drill the firewall as show in the following picture and fix the flying connector "Engine", securing it with the nut supplied.

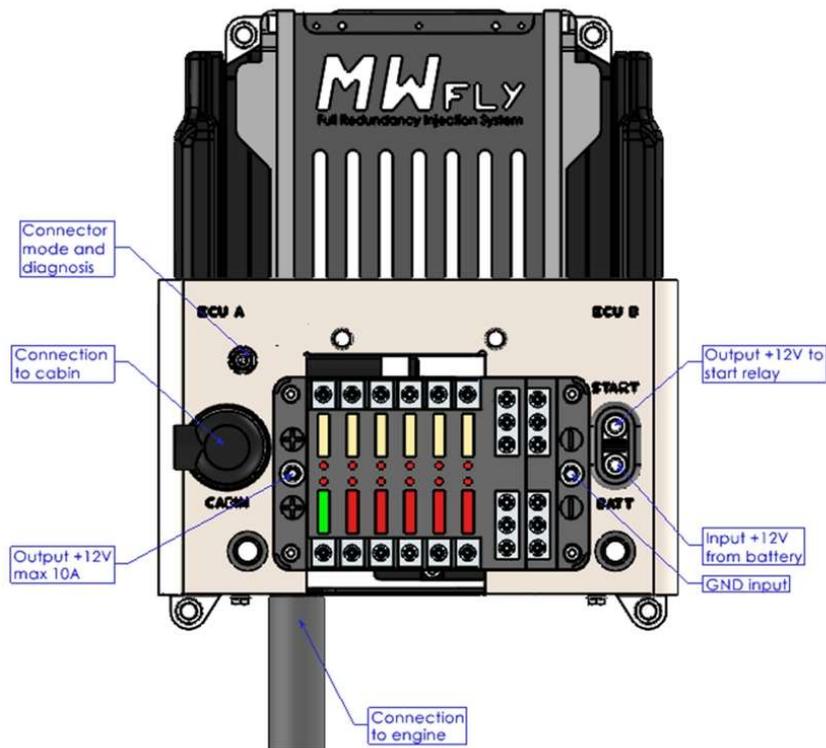


For all other IJ group installations, create a panel anchored to the aircraft frame and prepared with a hole for the "engine" connector.



Do not leave the "engine" connector loose as the vibrations could cause the wires to tear from the terminals.

- d. Connect the counterpart connector from the engine wiring from inside the engine compartment, engaging the ring nut until the safety lock is felt.
- e. A circular connector is fixed on the control unit group, which must be connected to the aircraft wiring: this connector is marked with the wording "CABIN".
- f. Connect the connector of the diagnostic lights and the "mode" button to the counterpart on the IJ-m above the "Cabin" connector; this connector may not be present on some engine versions.



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- g.** Connect the positive cable coming from the battery to the screw input marked with the word "Batt": tighten with M6 screw at 8Nm using a safety washer to be placed between the cable lug and the screw head.
- h.** Connect the starting cable coming from the remote-control switch to the connection called "Start" and secure it with an M6 screw tightened to 8Nm: also, in this case use a safety washer. Other heavy electrical loads can be connected to the same connection.



The current drawn from the "Start" connection is not read by the shunt present inside the IJ-m.

- i.** Connect the ground cable to the terminal marked with the symbol "-" on the fuse box: the M5 screw must be tightened to 4Nm and secured with a safety washer.



**For safety reasons it is advisable to connect a second ground cable to any of the unused screws located on the right side of the fuse box.**

- j.** Connect the power supply cable of the on-board utilities to the terminal marked with the "+" symbol on the fuse box, as long as the load does not exceed 10A.

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**Carefully check that all electrical connections are made and well insulated, to avoid short circuits which can in turn cause fires on board.**

<b>Cable Dimensions Table for IJ-m</b>			
	<i>Connettor/connection</i>	<i>Cable dimension [mm<sup>2</sup>]</i>	<i>note</i>
1	Cabian connector		See table 24-04-C
2	Diag&mode connector		See table 24-05-C
3	Power output for starter	25	
3	Power output other loads		Dimension the cable according to the load see table 24-07-C
4	Ingresso 12 V da batteria	25	
5	Uscita 12V altre utenze		Dimension the cable according to the load see table 24-07-C considering that the maximum total load is 10Amp
6	GND input	2.5	

76-08-C

<b>Cable Dimension Table - Max Continuos Load</b>			
	<i>Cable dimension [mm<sup>2</sup>]</i>	<i>A max continuous</i>	<i>wire</i>
1	0,5	6	CU 0.5 PR
2	1	11	CU 1 PR
3	1,5	14	CU 1,5 PR
3	2	16	CU 2 PR
4	2,5	20	CU 2,5 PR
5	4	28	CU 4 PR
6	6	37	CU 6 PR
7	8	48	CU 8 PR
8	10	53	CU 10 PR
9	15	67	CU 15 PR
10	25	100	CU 25 PR
11	35	125	CU 35 PR

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### 76-05-03 Battery

The engine is able to start and run with batteries having a minimum start current of 150 A. However, it is recommended to use batteries with a start current of at least 250 A. This also has higher capabilities to provide better reserve of charges.

The installation of the battery should be done in the following manner.

- a.** Place the battery closet for the engine paying particular attention to the balance of the aircraft.
- b.** Fix the battery in a steady and safe manner and avoid vibrational stress.
- c.** Connect the GND cable and VBATT+ cable using a big section cable at least of 25 mm<sup>2</sup>, or bigger in case the cables are longer than 1 meter.
- d.** Clean the battery clamps and remove any trace of oxidation. Attach the cable to the battery clamps and tighten enough to avoid any loosening. Periodically check if there is sign of oxidation on the battery clamps indicating that the contacts are too loose and that they need to be tightened.
- e.** Spread the battery clamps with anti-acid grease to maintain a good electrical connection.
- f.** In case the engine is used in cold weather conditions, use battery with high cranking current.
- g.** In case of use of the engine in hot weather condition, use power cable with bigger section size.

It is very important to maintain the battery in good condition to enable quick engine starts and steady working conditions of the engine's electronic components.



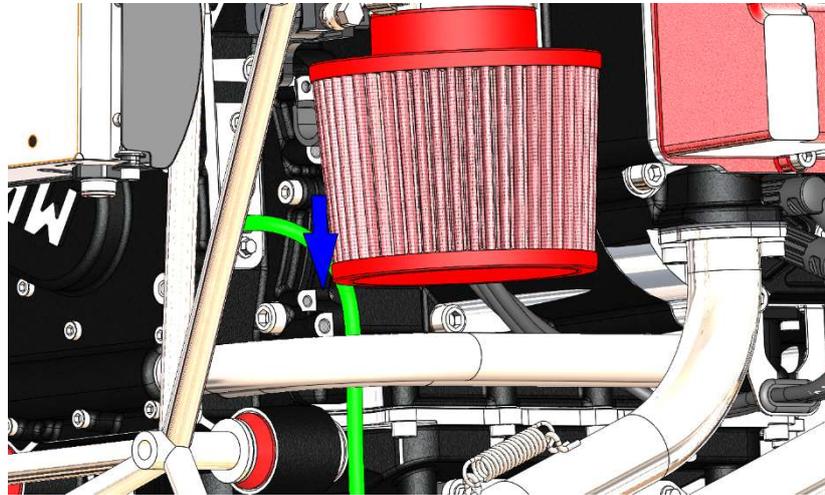
**In case of installation of the battery far away from the engine it is necessary to use a cable with bigger section size: an incorrect dimension of the power cable can cause overheating of the cable and fire.**



Connections made with cables of inadequate gauge or with screws not tightened properly can cause difficulty in starts and produce electromagnetic interference.

### 76-05-04 Engine GND

The points provided for the connection of the engine ground are two screws highlighted in the following figure, present in the lower rear part, bank side # 1: you can choose to connect the ground cable with a screw M8x1.25 (eyelet D8), or with one screw M6x1 (eyelet D6). The tightening torque of the screw is respectively 22 Nm or 12 Nm. It is advisable to use a cable as short as possible coming from the frame mass and with a section of not less than 17 mm<sup>2</sup> (AWG 5).



76-10-P



It is recommended to make two connections to ground the engine, using both positions indicated.



Connect the engine to ground is essential as the anti-vibration engine suspension system completely electrically isolate the engine from the aircraft ground.

#### 76-05-05 Starter System

Refer to paragraph 80-10-04.

#### 76-06-00 Verification and Validation

The electronic injection and ignition system are optimized to operate in any climatic and operating condition of the engine: this applies if the engine is installed according to the criteria described in this manual and with the original exhaust system. In this case it is only necessary to check the operating temperature of the IJ-m if it is located inside the engine compartment; the placement in the cabin does not normally present problems related to temperature.

If aerodynamic space constraints force installations in which some components of the engine are moved or modified (for example the exhaust system), it is necessary to remap the injection control unit. The tuning is carried out by installing a proportional lambda probe on the silencer: it is therefore necessary to prepare a suitable hole on the silencer, with M18x1.5 thread, positioned near the exhaust pipe (after the confluence of the four manifolds in the muffler).



Using the engine with an improperly calibrated injection system can cause lower performance, irregular operation or shutdown under certain conditions of use.

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In the event that the length or arrangement of the intake or exhaust manifolds or the volume of the silencer has been modified, it is mandatory to re-map the control unit.

Any anomalies in the injection system are highlighted by the ECU light coming on the EM-m instrument or by the diagnostic lights.

#### 76-06-01 *Measurement of the Operating Temperature of the Injection Control Unit*



The measurement of the operating temperature of the injection control units must be carried out only if they are located inside the engine compartment.

After installing the engine, check the temperature of the injection control unit by applying an irreversible liquid crystal thermometer as shown in the figure.



76-11-P

Normally the maximum temperature is reached immediately after the engine is turned off, when the heat accumulated during operation rises upwards.

If the temperature exceeds the limit value, it is necessary to improve ventilation in the engine compartment and heat dissipation, by opening one or more air intakes on the hood, preferably in the upper part.

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**Using the engine with injection control unit temperatures higher than the maximum allowed can cause it to stop suddenly and cause irreversible damage to the control unit itself.**

The control unit temperature measurement must be carried out as follows.

- a.** Carry out the test with air temperature above 25 ° C.
- b.** With the hood fully assembled, start the engine on the ground and, after warming it up, bring it to 3500 rpm for about 5 minutes at a fixed point.
- c.** Switch off the engine and the injection control unit and wait at least 15 minutes.
- d.** Check the temperature marked by the thermometer without turning the control unit back on.
- e.** Replace the thermometer, keeping the removed one for comparison. If the temperature is below the maximum limit, carry out a test flight lasting 10 ÷ 15 minutes and, after landing and having waited at least 15 minutes from switching off the engine, take a new reading.
- f.** If the reading indicates a temperature below the limit, it is possible to fly, keeping the thermometer in position and checking the temperature during flights on particularly hot days.
- g.** In the event that the temperature on the ground or in flight exceeds the limits, do not use the engine without first modifying the canopy in such a way as to decrease the temperature on the injection control unit.



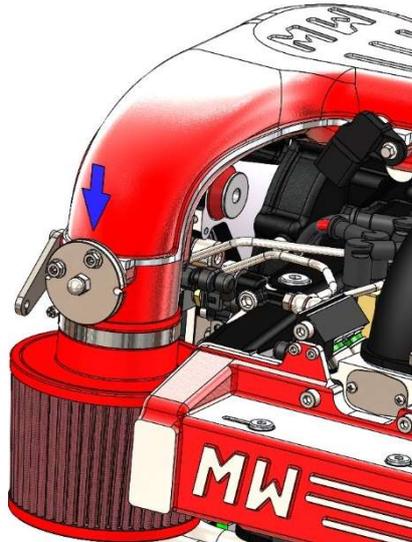
**If the limit has been exceeded for values above 15 ° C, the injection control unit must be checked before using it again.**

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## 76-10-00 Throttle Control

On the intake system, above the air filter, there is the throttle valve control cam and the stop bracket for the actuation Bowden cable.

### 76-10-01 Description



76-12-P

The minimum and maximum position of the cam can be adjusted by means of two dowels placed on the side of the cam itself: these adjusters are set by the factory and therefore, initially, it is not necessary to make any adjustments.

The adjustment of the stroke of the control cable can be performed using a threaded register with double M6 nut for anchoring the cable itself to the striker bracket.



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Two interconnected springs present on the throttle control cams bring the throttle in the open position: take account of this for the realization of the throttle control.

### 76-10-02 Cable Features

During installation it is only necessary to connect the lever positioned in the cabin to the control cam on the engine via a Bowden cable, considering the characteristics indicated below.

▪ Control cable material	stainless steel
▪ Section of the control cable	D1,2 mm
▪ Minimal tear strength	800 N
▪ Cable clamp seat diameter on throttle cam	5,5 mm
▪ Diameter for screw register on stop bracket	6 mm
▪ Sheath material	polyethylene
▪ Minimum radius of curvature	150 mm
▪ Total stroke of the cable	~35 mm
▪ Total load on the cable	~55 N
▪ Total throttle spring torque	0,37 Nm

### 76-10-03 Command Implementation

The throttle control is equipped with return springs, which reset the throttle to the fully open position. Take this particularity into account when setting up the control.



This feature allows, in the event of a break in the throttle control cable, to keep the engine running at maximum power in order to manage the emergency in the best possible way.



For particular applications, the accelerator control is available with return springs that close the throttle.

The installation of the throttle control must be done in accordance with what is prescribed below.

### Necessary Materials

1. Nylon hose clamps
  2. Shears
  3. Hard metal file
  4. Crimping tool for 6 mm diameter
  5. Other tools depending on the materials chosen during installation
- a.** Secure the sheath of the main branch to the engine mount or to the frame using appropriate clamps [1] that do not compress the sheath, to avoid vibration during use.

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- b.** Check that the cable does not contact or pass by hot spots in the engine or engine compartment; also check that the sheath does not come in contact with abrasive or sharp surfaces.
- c.** Mount [5] on the striker bracket on the power unit a screw adjuster, for fine adjustment of the cable travel.
- d.** Take the measurement of the length of the control cable and the sheath: the length of the cable must allow the throttles (throttle cams to be fully closed and opened).
- e.** Pull the sheath off the cable.
- f.** With the shears [2] cut the cable and sheath to length.
- g.** Carefully check that the coil spring present in the sheath has no sharp inward edges that could damage the cable during sliding: if necessary, eliminate these edges with a file [3] or a grinding wheel, having first protected the sheath from the ingress of the dust that will be produced.
- h.** Insert the lug on the cut end of the sheath and crimp it [4] to the sheath.
- i.** Reinsert the sheath onto the cable.
- j.** Fit the cable retainer provided on the cable on the throttle control cam side and tighten [5].
- k.** Insert the cable into the control lever.
- l.** Push the control carefully to the intended end of travel or to the position you wish to have at full power.
- m.** Tighten [5] the control cable to the lever with the intended system (by the installer).
- n.** Move the lever back until the throttles are brought to a closed stop: at this position, the throttle lever end stop must be secured so that the throttle cable is not pulled beyond the end stop.



If you do not set a limit switch on the accelerator control lever, in addition to putting excessive strain on the cable, you can cause the throttle to block, making it impossible for the engine to reach the power necessary for flight.

- o.** Operate the throttle lever repeatedly between the maximum and minimum open positions, and check that there is no snagging or excessive strain in the control. Also check that the closing and opening end-stroke occurs correctly. Any minor stroke corrections are possible by acting [5] on the screw adjuster.
- p.** When the thruster is first turned on, check that in cable is not pulled or otherwise stressed as a result of vibration due to operation.
- q.** Move the lever back until the throttles are fully closed: in correspondence with this position it is necessary to fix the stroke end of the throttle lever, so as not to stress the traction throttle cable over the stroke end.

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Once the check on the throttle cable actuation is complete, it is a good idea to provide for welding the clamping nipples to the cable to prevent unwanted loosening.

It is appropriate for the lever to be equipped with a friction mechanism, possibly adjustable, that can counteract and restrain the action of the return springs mounted on the throttle actuation cams. The springs installed on the thruster return the control to the open position in the absence of pull on the actuating cam.

Make sure that the closing end stop of the throttle lever located in the cabin (idle) coincides with the end stop of the throttle control cam. This precaution is necessary to prevent the cable from being subjected to excessive pull in the open end-of-stroke condition.

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## 77-00-00 ENGINE INDICATING

### 77-01-00 Sensors

#### Standard Sensors

Each engine has a preassembled set of sensors, as detailed below.

- Main control unit motor revolutions
- Auxiliary power unit motor revolutions
- Bank #1 liquid temperature
- Bank #2 liquid temperature
- Engine oil temperature
- Intake air temperature
- Barometric pressure
- Manifold air pressure (MAP)
- Engine oil pressure safety switch
- Throttle position sensor

The characteristics of the sensors provided in the standard equipment are given in the following sections of this chapter.

#### Additional Sensors

The engine is prepared for the installation of additional sensors than those provided in the standard equipment. Some of the sensors below are also present in the standard equipment (highlighted in bold): in the case it is not possible to use the CAN data export line of the injection system, it is mandatory to use the provisions to install additional sensors, as it is not possible to split the signal of the standard sensors present.

- **Engine oil temperature**
- **Bank #1 liquid temperature**
- **Bank #2 liquid temperature**
- **Intake air temperature**
- Gearbox oil temperature
- Fuel temperature
- **Manifold air pressure (MAP)**
- Engine oil pressure (sensor)
- Fuel pressure
- Lambda sensor

The characteristics of the preinstalled sensors are provided in the following sections of this chapter.



**Installation operations should be carried out with the engine cold and switched off.**

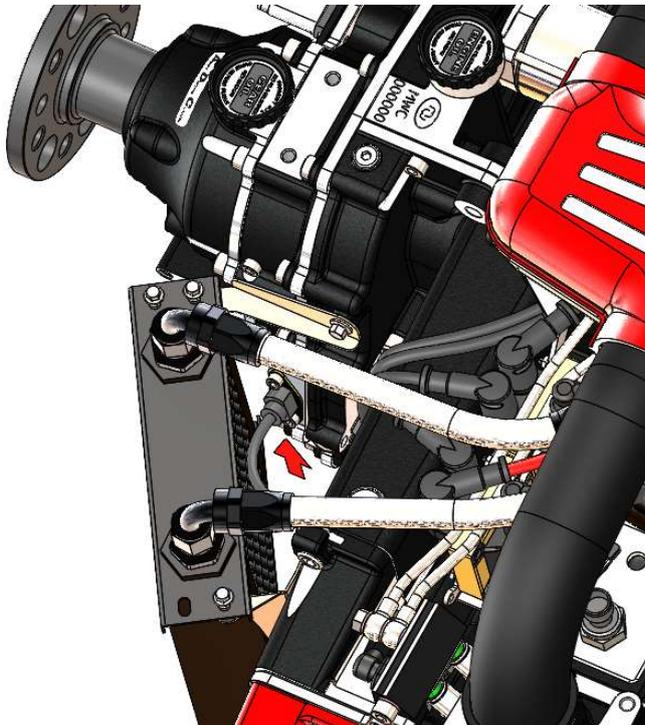
**A**

Under no circumstances should the mounting of the instrumentation interfere with the engine wiring: therefore, do not make any connections, shunts, or modifications to the engine wiring, as it will likely affect the reliability and safety of the installation.

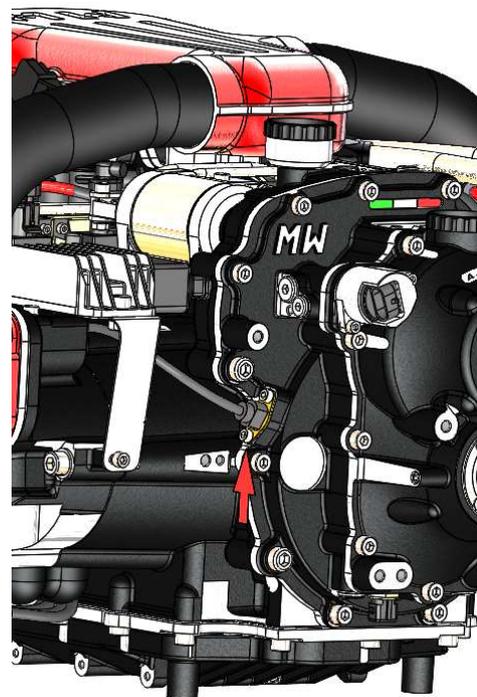
### 77-01-01 Rev Counter Signal

#### Standard Sensor Position

Two rpm captors are installed on each engine, each sending the signal to one of the two injection units. Both are installed on the gearbox (or on the front cover for direct engines): the primary captor is installed on the #2 bank side, behind the oil cooler; the secondary captor is installed symmetrically, on the #1 bank side.



77-01-P



77-02-P

The signal provided by these sensors is processed by the injection control units and made available on the CAN line.

**A**

The preinstalled engine RPM sensors must not under any circumstances be removed, nor should their signal be intercepted to send it to a measuring instrument, as this would alter the value, causing malfunctions in the engine.

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In case the EM-m instrument or an instrument equipped with CAN Aerospace input is used, the engine revolutions are provided by the preinstalled sensors, and therefore no additional sensor needs to be installed.

### Provision for Additional Sensor

For analog type instruments or otherwise not equipped with CAN input, the rev signal can be read directly from the rev signal output of the ECU assembly, referring to the diagram in this manual.

### Signal Characteristics

The characteristics of the engine speed signal output from the ECU are as follows:

- Signal output type    grounding switch
- Frequency            4 pulses per round



Check with the manufacturer of the engine RPM display instrument for signal compatibility with the instrument itself. For some instruments it may be necessary to insert an appropriate pull-up resistor between the signal and the 12V battery or between signal and a VREF output of the instrument itself.

### Installation

To handle this data correctly, proceed as follows.

- a.** Insert into the counterpart of the Cabin connector on IJ-m the contact for the engine RPM signal at connector position 13.
- b.** Crimp the contact to the opposite side of the contact, together with another piece of cable: insert the contact into the connector.
- c.** If necessary, insert pull-up resistor as required by the manufacturer of the instrument in use.
- d.** Make all the remaining connections provided for connecting the chosen instrument to the system.
- e.** Turn on the engine and check the consistency of the value read on the instrument over the entire engine speed range.



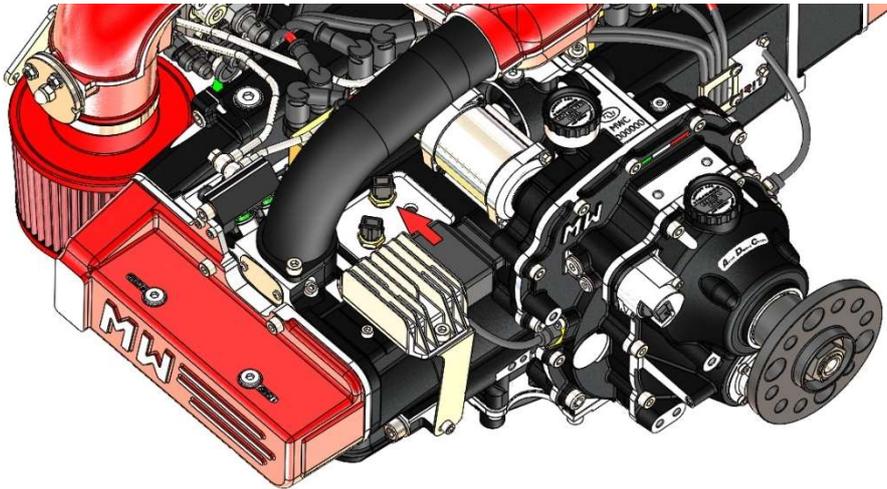
Avoid picking up the engine RPM signal any other way: in addition to getting a dirty signal, you risk interfering with the ignition system and damaging the injection control unit.

### 77-01-02 Coolant Temperature Sensor

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### Standard Sensor Position

Two coolant temperature sensors are installed on each engine, one on each bank: at that location the sensors measure the temperature coming out of the engine heads.



77-03-P



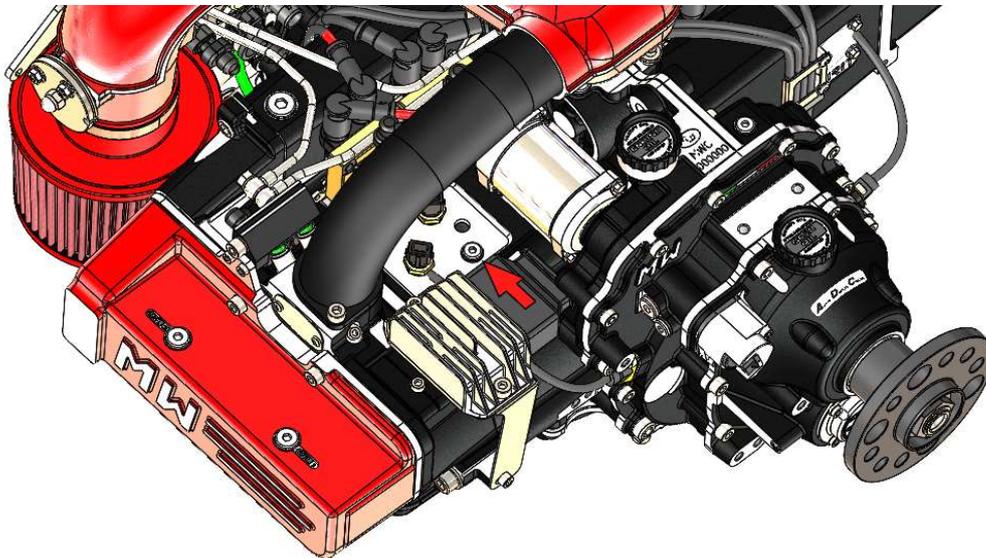
The preinstalled liquid temperature sensors must not under any circumstances be removed, nor should their signal be tapped to send it to a measuring instrument, as this would alter the value, causing malfunctions in the engine.



In case the EM-m instrument or an instrument with CAN Aerospace input is used, the coolant temperature is provided by the preinstalled sensors, and therefore no additional sensor needs to be installed.

### Provision for Additional Sensor

Provision for mounting an additional sensor is on both banks, near the standard sensor.



77-04-P

### Sensor Characteristics

The characteristics of the standard sensor are as follows.

- Type resistive (NTC) with isolated ground
- Measuring range -30÷150 °C
- Mounting thread M12x1.5
- Resistance to chemicals inert to prolonged contact with ethylene glycol

The minimum characteristics of the additional sensor are as follows.

- Type resistive (NTC) with isolated or separate
- Measuring range 50÷120 °C
- Mounting M10x1
- Resistance to chemicals inert to prolonged contact with ethylene glycol

### Installation

The installation of the sensors should be done as follows.

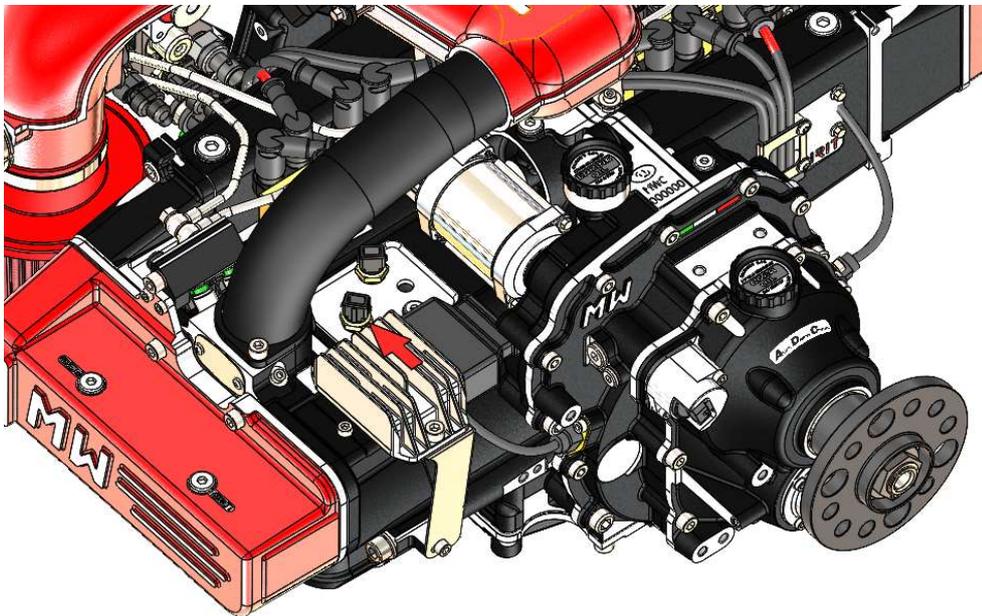
- a.** Remove the intake system.
- b.** Drain the cooling system.
- c.** Remove the M10x1 plug from the predisposition holes on both banks; also remove the copper gasket.
- d.** Install the sensor in the pre-drilled hole, interposing the prescribed gasket; weak threadlocker is recommended on the threads.
- e.** Tighten to the torque prescribed by the sensor manufacturer.
- f.** Connect the connector provided to the sensor.

- g.** Refill the cooling system.
- h.** Reinstall the intake system.

### 77-01-03 Engine Oil Temperature Sensor

#### Standard Sensor Position

An engine oil temperature sensor is installed on the #1 bank of the engine: in this position, the sensor detects the oil temperature on the sending channel to the cylinder head.



77-05-P



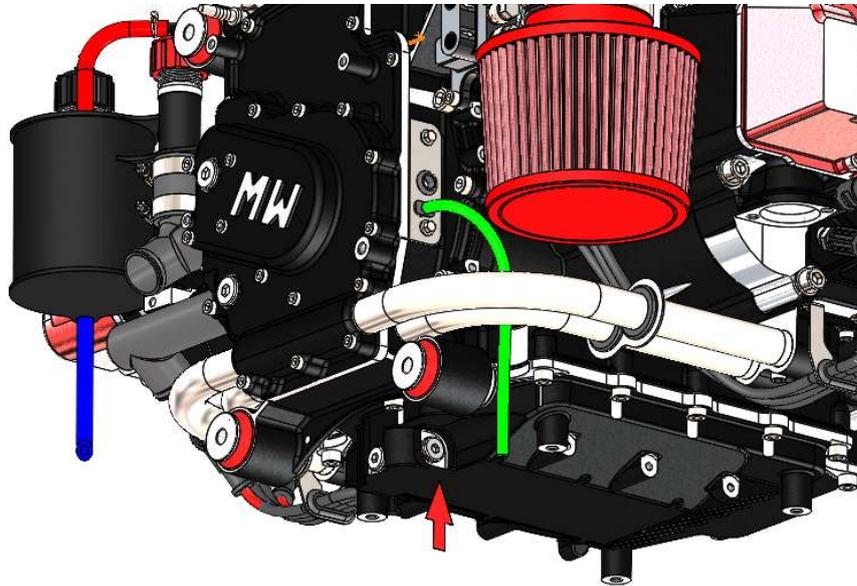
The preinstalled engine oil temperature sensor must not under any circumstances be removed, nor should its signal be tapped to send it to a measuring instrument, as this would alter its value, causing malfunctions in the engine.



In case the EM-m instrument or an instrument with CAN Aerospace input is used, the engine oil temperature is provided by the preinstalled sensor, and therefore no additional sensor needs to be installed.

#### Provision for Additional Sensor

The provision for mounting an additional sensor is on the oil sump at the location shown in the figure.



77-06-P

### Sensor Characteristics

The characteristics of the standard sensor are as follows.

- Type resistive (NTC) with isolated ground
- Measuring range  $-30 \div 150 \text{ }^{\circ}\text{C}$
- Mounting M12x1.5
- Resistance to chemicals inert to prolonged contact with synthetic-based lubricants

The minimum characteristics of the additional sensor are as follows.

- Type resistive (NTC) grounded to frame or with isolated ground
- Measuring range  $50 \div 150 \text{ }^{\circ}\text{C}$
- Mounting thread M12x1.5
- Resistance to chemicals inert to prolonged contact with synthetic-based lubricants

### Installation

The installation of the sensors should be carried out as follows.

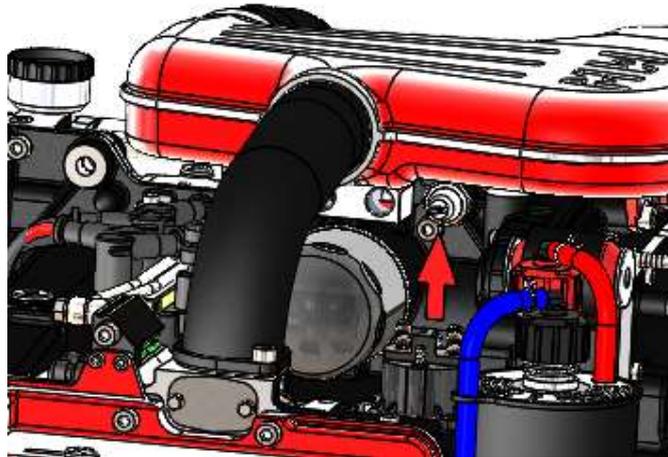
- a.** Remove the engine oil.
- b.** Remove the M12x1.5 plug from the predisposition hole on the sump, bank side #1; also remove the copper gasket.
- c.** Install the sensor in the prepared hole, interposing the provided gasket; weak threadlocker is recommended on the threads.
- d.** Tighten to a torque of 20 Nm.
- e.** Connect the provided connector to the sensor.

**f.** Refill the engine oil.

#### *77-01-04 Oil Pressure Sensors*

##### Standard Pressure Sensor

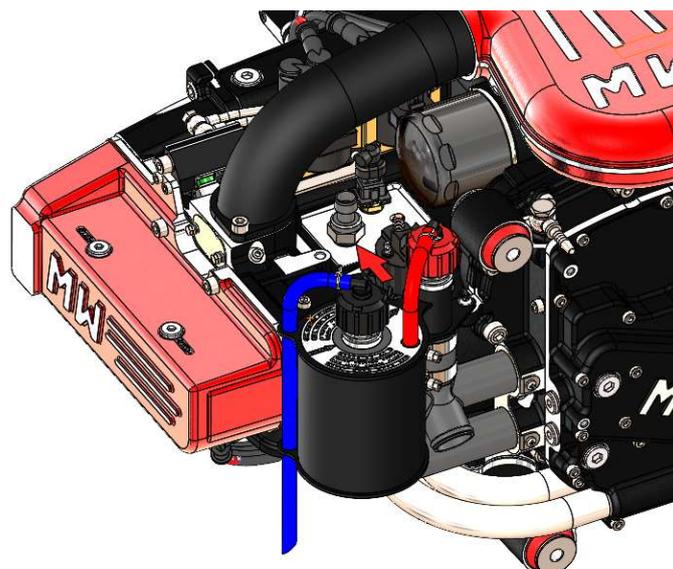
There is no sensor for reading the engine oil pressure value in the standard equipment: however, there is a switch that sends a signal if the engine oil pressure is insufficient.



*77-07-P*

##### Provision for Additional Sensor

Provision for mounting an oil pressure sensor is on the top of the #2 bank.



*77-08-P*

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### Sensor Characteristics

The characteristics of the standard switch are as follows.

- Calibration pressure 1,8 bar
- Mounting thread M10x1
- Resistance to chemicals inert to prolonged contact with synthetic-based lubricants

The most suitable additional pressure sensor is the piezoresistive type: however, variable resistance passive type sensors (rheostats) can also be installed, provided they are equipped with the appropriate reading instrument. The characteristics of the sensor to be used are as follows.

- Type piezoresistive or variable resistance
- Measuring range 0÷5 bar
- Mounting thread 1/4" gas
- Resistance to chemicals inert to prolonged contact with synthetic-based lubricants

### Installation

The sensor should be installed as follows and without necessarily removing the lubrication oil.

- a.** Remove the intake system.
- b.** Remove the ¼" gas cap from the predisposition hole on the #2 bank; also remove the copper gasket.
- c.** Install the sensor in the prepared hole, interposing the provided gasket; weak threadlocker is recommended on the threads.
- d.** Tighten to 30 Nm.
- e.** Connect the connector provided to the sensor.
- f.** Check the engine oil level and top up if necessary.
- g.** Reinstall the intake system.

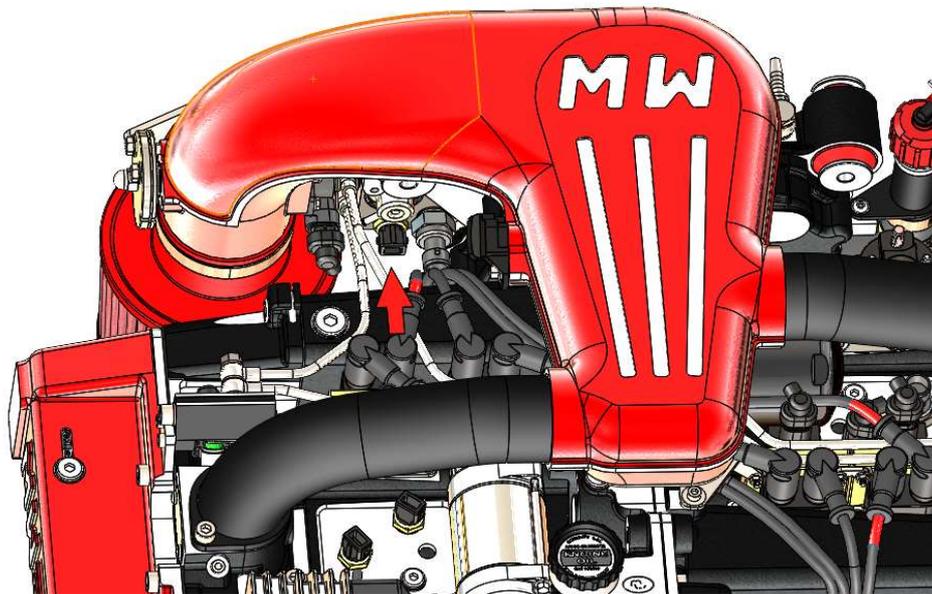
### 77-01-05 Fuel Temperature Sensor

#### Standard Sensor Position

There is no sensor for reading the fuel temperature value in the standard equipment.

#### Provision for Additional Sensor

Provision for mounting a fuel temperature sensor is on the fuel distributor, located at the rear of the engine.



77-09-P

### Sensor Characteristics

The minimum characteristics of the sensor to be used are as follows.

- |                           |   |
|---------------------------|---|
| ▪ Type                    | resistive (NTC) grounded to frame or with isolated ground |
| ▪ Measuring range         | 50÷150 °C   |
| ▪ Mounting                | thread M12x1.5  |
| ▪ Resistance to chemicals | inert to prolonged contact with gasoline and alcohol      |



**It is of absolute importance to use only sensors suitable for use with gasoline, as other types of sensors could be damaged causing pressure loss in the system and fires from fuel spillage on hot engine parts.**

### Installation

The installation of the sensor should be done as follows.



**Keep in mind that you are working near highly flammable liquids that are harmful if inhaled and ingested.**

- a. Remove pressure from the fuel system, as described in the maintenance manual.
- b. Remove the supply air filter.
- c. Remove the M12x1.5 plug from the predisposition hole in the rear of the distributor; also remove the copper gasket.

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- d.** Install the sensor in the predisposition hole, interposing the gasket provided; it is recommended to use weak threadlocker on the thread.
- e.** Tighten to 20 Nm.
- f.** Connect the connector provided to the sensor.
- g.** Operate the fuel pumps and bleed them.
- h.** Check for leaks near the installed sensor.
- i.** Reinstall the fuel air filter.

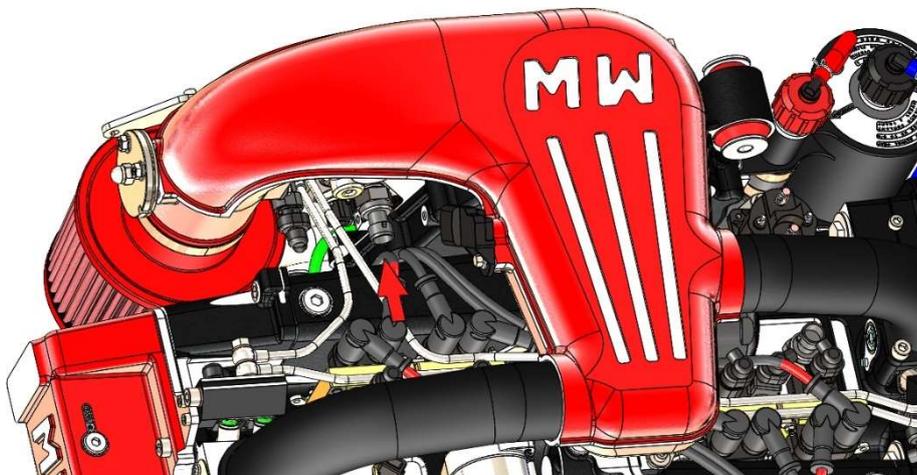
### 77-01-06 Fuel Pressure Sensor

#### Standard Sensor Position

No sensor is provided in the standard equipment to read the fuel pressure value.

#### Provision for Additional Sensor

Provision for mounting a fuel pressure sensor is on the fuel distributor, located at the rear of the engine.



70-10-P

#### Sensor Characteristics

The most suitable sensor is the piezoresistive type: however, variable resistance passive type sensors (rheostats) can also be installed, provided they are equipped with the appropriate reading instrument. The minimum characteristics of the sensor to be used are as follows.

- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>▪ Type</li> <li>▪ Measuring range</li> <li>▪ Mounting</li> <li>▪ Resistance to chemicals</li> </ul> | piezoresistive or variable<br>resistance<br>0÷5 bar<br>thread 1/4" gas<br>inert to prolonged contact with<br>gasoline and alcohol |
|--|---|

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**It is of absolute importance to use only sensors suitable for use with gasoline, as other types of sensors could be damaged causing pressure loss in the system and fires from fuel spillage on hot engine parts.**

### Installation

The installation of the sensor should be done as follows.



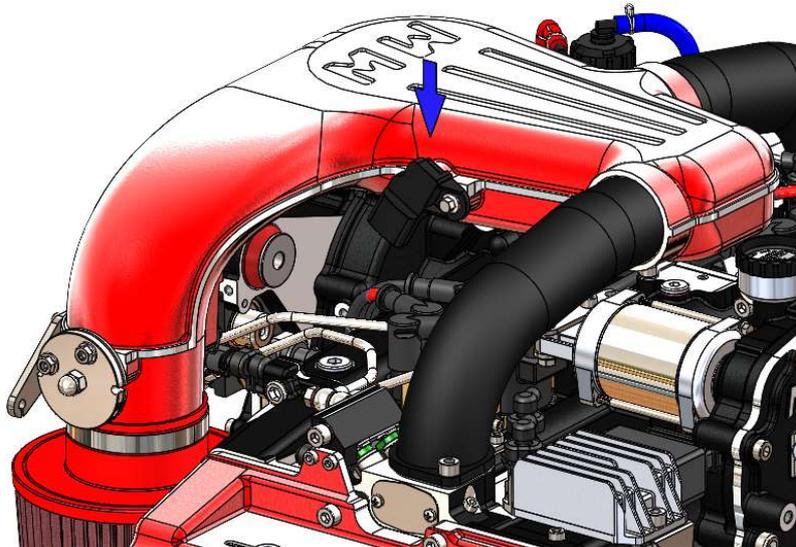
**Keep in mind that you are working near highly flammable liquids that are harmful if inhaled and ingested.**

- a.** Remove pressure from the fuel system, as described in the maintenance manual.
- b.** Remove the supply air filter.
- c.** Remove the ¼" gas cap from the predisposition hole in the rear of the distributor; also remove the copper gasket.
- d.** Install the sensor in the predisposition hole, interposing the gasket provided; it is recommended to use weak threadlocker on the thread.
- e.** Tighten to 30 Nm.
- f.** Connect the connector provided to the sensor.
- g.** Operate the fuel pumps and bleed them.
- h.** Check for leaks near the installed sensor.
- i.** Reinstall the fuel air filter.

### *77-01-07 Air Intake Temperature Sensor*

#### Standard Sensor Position

A supply air temperature sensor located on the airbox on the #1 bank side is installed on the engine: the signal is sent to the injection control unit, which processes it to adjust the mixture ratio.



77-11-P



The pre-installed supply air temperature sensor should not be removed under any circumstances, nor should its signal be tapped to send it to a measuring instrument, as this would alter its value, causing malfunctions in the engine.



In the case of using the EM-m instrument or an instrument equipped with CAN Aerospace input, the supply air temperature is provided by the preinstalled sensor, and therefore no additional sensor needs to be installed.

### Provision for Additional Sensor

There is no provision for an additional air temperature sensor.

### Sensor Characteristics

The characteristics of the sensor are as follows.

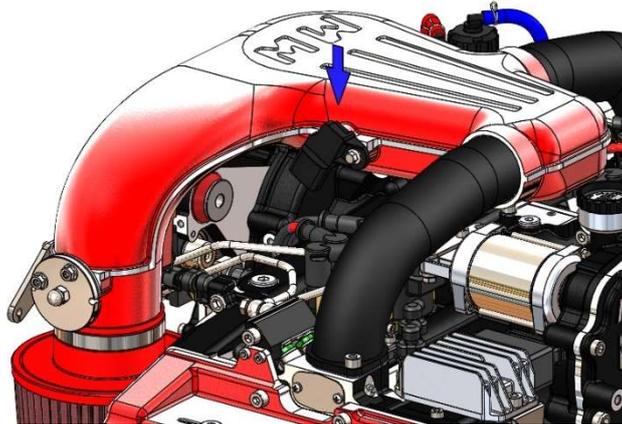
- |                           |  |
|---------------------------|--|
| ▪ Type                    | resistive (NTC) with isolated ground           |
| ▪ Measuring range         | -30÷150 °C                                     |
| ▪ Mounting                | plug-in with retaining screw                   |
| ▪ Resistance to chemicals | inert to prolonged contact with green gasoline |

77-01-08 MAP (Manifold Air Pressure) Sensor

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### Standard Sensor Position

The manifold air pressure (MAP) sensor is on the airbox on the #1 bank side: this sensor, in addition to pressure, also measures the temperature of intake air.



77-12-P



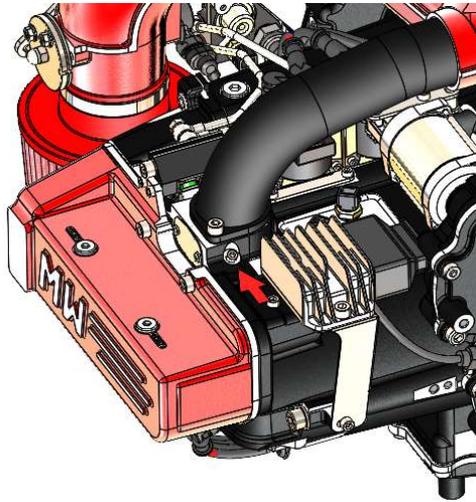
The preinstalled supply air pressure sensor must not under any circumstances be removed, nor should the signal be tapped to send it to a measuring instrument, as this would alter the value, causing malfunctions in the engine.



In the case of using the EM-m instrument or an instrument equipped with the Aerospace CAN input, the MAP value is provided by the preinstalled sensor, and therefore no additional sensor needs to be installed.

### Provision for Additional Sensor

Provision for mounting an additional sensor is present on both cylinder heads, near the intake manifold connection on the cylinder heads.

*77-13-P*

The pressure tap and pipe can be installed either on header #2 or #1, although the former option is preferred. The following describes the installation of an electronic type sensor, which can be requested as an option. However, it is also possible to read the MAP signal with a pneumatic instrument, using the same pressure sockets.

### Sensor Characteristics

The characteristics of the standard sensor are as follows.

- |                           |  |
|---------------------------|--|
| ▪ Type                    | piezoresistive                                       |
| ▪ Measuring range         | 10÷115 kPa   |
| ▪ Mounting                | plug-in with retaining screw                         |
| ▪ Resistance to chemicals | inert to prolonged contact with gasoline and alcohol |

The minimum characteristics of the additional sensor to be used are as follows.

- |                           |   |    |                     |
|---------------------------|---|----|---------------------|
| ▪ Type                    | piezoresistive  | or | variable resistance |
| ▪ Measurement range       | 30÷105 kPa  |    |                     |
| ▪ Tube inner diameter     | 4 mm  |    |                     |
| ▪ Pressure tapping thread | M5x0.8mm  |    |                     |
| ▪ Maximum tube length     | 500 mm  |    |                     |
| ▪ Tube type               | suitable for pressure ranges from 0.2 to 1.5 bar (absolute) |    |                     |
| ▪ Resistance to chemicals | inert to prolonged contact with green gasoline              |    |                     |

### Installation

The installation of the sensor should be as follows.

- a.** Remove the set-up hole capping screw.

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- b.** Screw a hose holder with M5 threading to the predisposition hole; use a weak threadlocker compound and tighten to 5 Nm.
- c.** Attach the chosen MAP sensor to the engine or aircraft, in a position not too far from the pressure port and possibly higher, to avoid possible fuel build-up in the pipe.
- d.** Connect the hose at both ends and secure it so that it cannot come loose during use.
- e.** Connect the connector provided to the sensor.

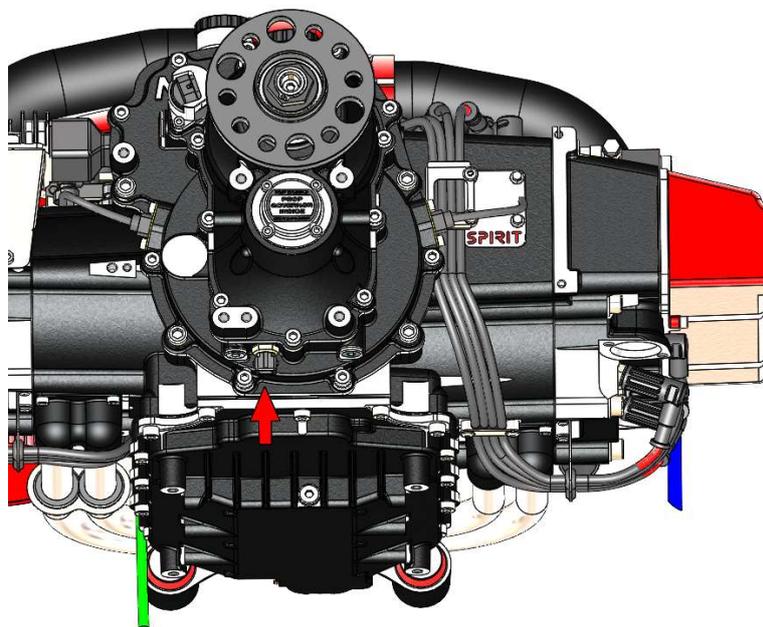


Make sure there is no venting from the connections, which can affect the smoothness of running, especially at low engine speeds and low loads.

### 77-01-09 Gearbox Oil Temperature Sensor

#### Standard Sensor Position

Versions equipped with a hydraulic propeller governor system have a preinstalled gearbox oil temperature sensor located at the bottom of the gearbox. The signal from that sensor is sent to the electronic propeller pitch control module to adjust the responsiveness of the system to the change in lubricant viscosity as a function of operating temperature.



77-14-P

#### Provision for Additional Sensor

An additional gearbox oil temperature sensor cannot be installed.

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### Sensor Characteristics

The characteristics of the sensor are as follows.

- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>▪ Type</li> <li>▪ Measuring range</li> <li>▪ Mounting</li> <li>▪ Resistance to chemicals</li> </ul> | <ul style="list-style-type: none"> <li>resistive (NTC) with isolated ground</li> <li>-30÷150 °C</li> <li>M12x1.5</li> <li>inert to prolonged contact with synthetic-based lubricants</li> </ul> |
|--|---|



The gearbox lubricant temperature sensor, if preinstalled, should not under any circumstances be removed, nor should its signal be tapped to send it to a measuring instrument, as this would alter its value, causing malfunctions in the governor.

### Installation

The installation of the sensor should be as follows.

- a.** Drain the gearbox of lubricant, as described in the maintenance manual.
- b.** Remove the M12x1.5 plug from the predisposition hole indicated; also remove the copper gasket.
- c.** Install the sensor in the predisposition hole, interposing the provided gasket; weak threadlocker is recommended on the thread.
- d.** Tighten to the torque prescribed by the sensor manufacturer.
- e.** Connect the sensor to a suitable reading instrument, taking care that the wiring cannot interfere with the moving propeller.
- f.** Fill the gearbox with lubricant.



No other position other than the one specified above is to be considered valid for the application of the gearbox oil temperature sensor.

### 77-01-10 Oxygen Sensor (Optional)

If, during installation, significant changes are made to the intake or exhaust system, it is essential to detect and, if necessary, correct the carburetion. In this case it is necessary to use the lambda sensor.



77-15-P

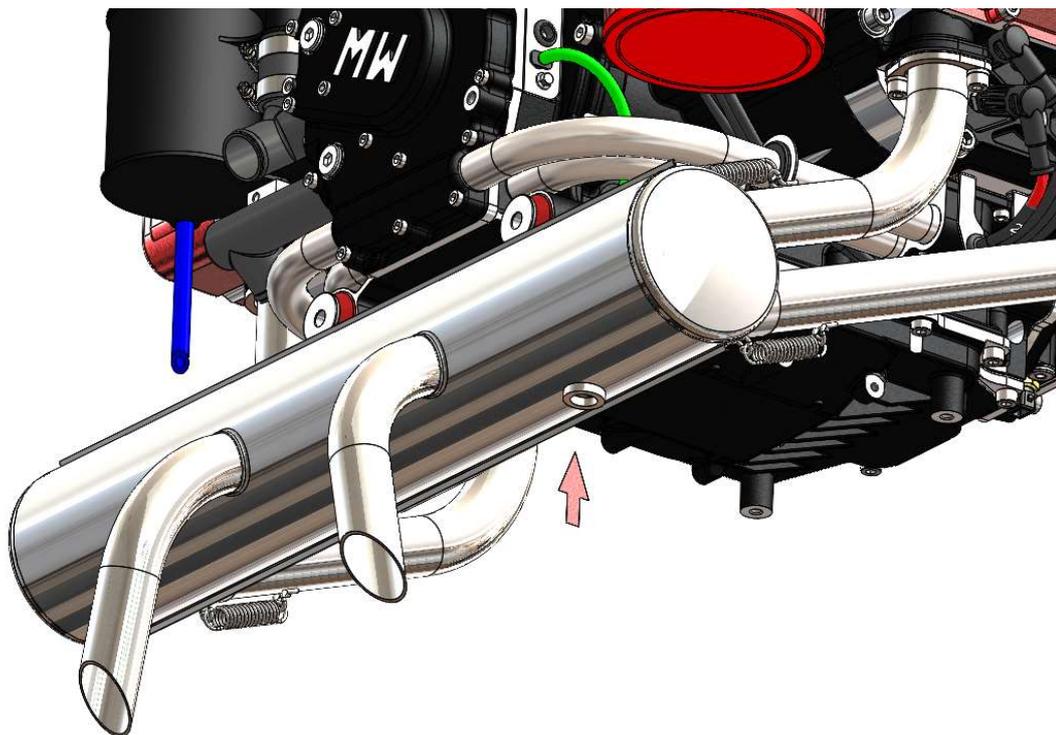
	<b>Installation Manual for SPIRIT engines</b>	Document <b>E-DMA.E10.1</b>	
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### Standard Sensor Position

No lambda sensor is included in the standard equipment.

### Provision for Additional Sensor

Provision for mounting a lambda sensor is provided on the original muffler supplied as optional.



77-16-P

The oxygen sensor detects the amount of oxygen present in the exhaust gas: the value can be displayed by an EFIS or EMS instrument, or it can be sent to the injection control unit, and from there transmitted on a CAN line to the on-board instruments. In the former case, the electrical connection must be made in the manner prescribed by the instrument manufacturer.

### Sensor Characteristics

The minimum characteristics of the sensor to be used are as follows.

- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>▪ Type</li> <li>▪ Measuring range</li> <li>▪ Mounting</li> <li>▪ Resistance to chemicals</li> </ul> | <ul style="list-style-type: none"> <li>proportional with power controller and feedback on temperature</li> <li>0,7÷1,3 λ</li> <li>thread M18x1.5</li> <li>inert to prolonged contact with gasoline and alcohol</li> </ul> |
|--|---|

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## Installation

To install the sensor on the exhaust, operate as follows.



**Before working on the exhaust, wait for it to cool completely to avoid dangerous burns.**

- a.** Unscrew the plug from the predisposition hole, with M18x1.5 thread, and remove the gasket washer.
- b.** Sprinkle a moderate amount of high-temperature copper grease on the sensor thread.
- c.** Screw the sensor into the housing, tightening to a torque of 45 Nm.
- d.** Mount the connector provided on the sensor.
- e.** Turn on the engine and check that there are no vents between the sensor and muffler.

## 77-40-00 Cabin Instrument

### 77-40-01 Engine Monitor Module (EM-m)

The EM-m instrument, described below, is equipped with a CAN line, and is therefore capable of reading all the information managed by the ECU group; it comes with the wiring harness and all the additional sensors listed above and not included in the standard equipment, with the exception of the lambda sensor.

Other instruments equipped with a CAN line, can receive information from the ECU group via the Aerospace CAN interface.

If analog instruments or instruments not equipped with CAN line are used, the appropriate sensors must be connected to them, without interfering in any way with the sensors preinstalled and managed by the injection system.



77-17-P

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The EM-m (Engine Monitor module) instrument is supplied as an option and can be configured for each engine model: the display shows the values of all standard and additional sensors provided (except for the lambda parameter), as well as the hours of operation, battery charging voltage and current, instantaneous consumption and fuel consumed since start-up; the display includes the ignition and ECU failure warning lights, generator failure warning lights (including auxiliary), and the take-off consent light, allowing the instrument panel to be simplified. The EM-m can be equipped with an inertial platform, thus also becoming a valuable tool for navigation.

When using the HG-m governor module, the desired rpm setting is done through the knob on the instrument, which also displays the target rpm value.

Please refer to the instrument manual for the list of functions, the correct way of use, and installation methods.



Do not perform flights or ground tests until you have read and understood the instrument user's manual.



Do not start the engine before electrically connecting the instrument to the wiring harness, as the system will detect the event as a fault.

**78-00-00 EXHAUST****78-01-00 Crankcase Vent**

The engine's internal venting system provides for the elimination of blow-by gases and water vapor condensation created in the first moments of operation. Oil vapours are vented through a labyrinth system built into the engine; the blow-by gases are then vented through the hole in the rear cover, to which a hose must be properly connected.



78-01-P



Do not exceed the prescribed oil level, as too much oil may cause the excess to escape through the vent system.



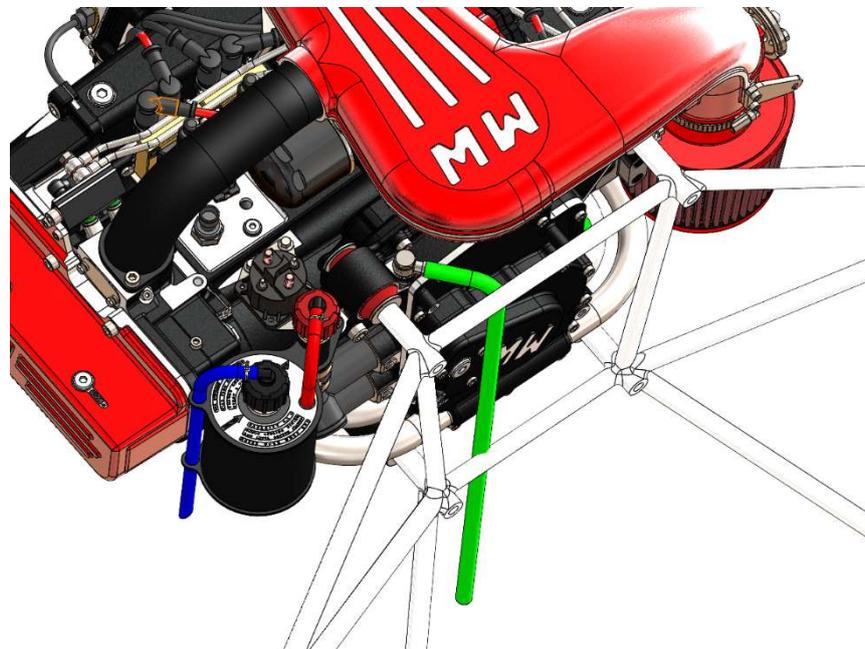
Modifying the internal ventilation system is potentially dangerous as it can impair performance and cause lubricant to leak from the engine.

**78-01-01 Making the Crankcase Vent**

Engines are delivered with the crankcase vent fitting mounted: this fitting has 8mm hose holder, which, if necessary, can be rotated. A hose with the following characteristics must be connected to the fitting.

- Type oil-resistant rubber or silicone
- Inner diameter 8 mm
- Maximum operating temperature 120 °C

The length of the pipe is decided by the installer: it is best to make sure that the vent pipe comes out of the cowling in the low position.



78-02-P

### Necessary Materials

1. Torque wrench
  2. Socket wrench 17 mm
  3. Other tools depending on the materials chosen during installation
- 
- a.** Slip the hose onto the hose holder screwed onto the rear cover and tighten it in place [3] with a hose clamp.
  - b.** Check which is the most suitable angular position for the fitting attachment. Tighten it in position [1+2] to a torque of 20Nm, interposing the copper washers provided.
  - c.** Position the vent pipe in the cowling so that it is away from the exhaust system. Secure it to the engine frame or other parts with hose clamps.
  - d.** Cut the hose to length so that oil vapours can escape from the engine cowling.
  - e.** Check after the first few flights that there is no oil stagnation in the hose, a sign of overpressure at the free end of the hose: if so, the free end of the hose should be placed elsewhere.

### **78-20-00 Exhaust System**

The engine has four separate exhaust ports facing the underside of the engine: this allows to design exhaust manifolds with a linear pattern and easy cooling.

A good exhaust system is essential for good performance and smooth operation from the engine. Also consider that the exhaust system is often a source of failure and overheating of aircraft parts.

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**When installing the exhaust system, take great care in avoiding overheating of aircraft or engine parts by the manifolds or muffler.**



A poorly designed exhaust system is a source of problems to the engine: it is therefore essential to comply with the requirements below when using a non-original exhaust system.

### 78-21-00 Exhaust Scheme Choice

To keep the weight and complexity of the exhaust system down, it is preferable to use a single muffler for the four cylinders, placed transversely under the engine and with direct entry of the four exhaust manifolds. An alternative involves merging the four-exhaust manifold from the headers into a single manifold, and then entering the muffler.

If maximum performance is to be favoured, it is advisable to use exhaust manifolds of equal length. On the other hand, to favour progression and torque uniformity at varying rpm, it is preferable to use manifolds of different lengths. It is advisable, however, that the difference in length between the shortest and the longest manifold is not excessive, to avoid running irregularities.

#### Benefits 4-in-1 Scheme

- Best compromise between silence and performance
- Smoothness of engine running, especially at idle
- Robustness

#### Disadvantages 4-in-1 Scheme

- Increased weight
- Increased temperature in the engine's cowling

A variant of such a scheme is the 4-in-2-in-1: again, it is important that the length of the two manifolds before joining be very similar, to avoid problems of exhaust backpressure.

Advantages and disadvantages of such a scheme are about the same as those already described.

Another possible scheme is the 4-in-2, in which the two manifolds of the same bank merge into a common manifold and then into a muffler, or directly into two mufflers, one for each bank. In this case it is essential that the two mufflers be identical to each other, and also the length of the manifolds of the two banks. Normally this is not an advantageous scheme.

#### Benefits 4-in-2 Scheme

- Less difficulty in inserting into the cowling

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### Disadvantages 4-in-2 Scheme

- Greater weight
- Greater irregularity at idle

Finally, it is also possible to make exhaust systems that do not include any type of muffler after the exhaust manifolds.

In this case, a manifold must be connected to each exhaust port, with sufficient length to move the exhaust gases away from the engine cowling, to avoid burning. With such an exhaust configuration, the noise level increases considerably, without, however, achieving significant increases in power; this solution, however, allows for the elimination of the weight of the muffler, which can be estimated at about 4 kilograms.

### Advantages of Free Discharge Scheme

- Less difficulty in inserting into the cowling
- Less weight
- Lower temperature inside the engine cowling

### Disadvantages of Free Discharge Scheme

- Increased noise
- Increased irregularity at idle



However, exhaust noise emissions must be kept within the limits imposed by the laws of the country where the engine is used.

## **78-22-00 General Features**

### *78-22-01 Location and Size of Discharge Flanges*

<b>Direct Version</b>				
<b>Flange position</b>	<i>Cylinder manifold #1</i>	<i>Cylinder manifold #2</i>	<i>Cylinder manifold #3</i>	<i>Cylinder manifold #4</i>
<i>Position in x</i>	174	349	264	439
<i>Position in y</i>	272,7	272,7	-272,7	-272,7
<i>Position in z</i>	-29	-29	-29	-29

78-01-C

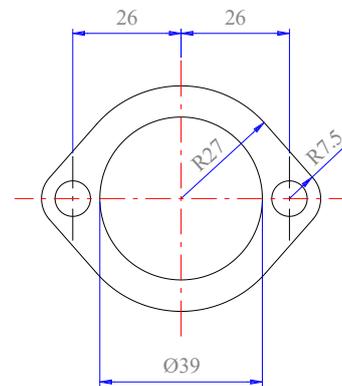
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<b>PSRU Version</b>				
<b>Flange position</b>	<i>Cylinder manifold #1</i>	<i>Cylinder manifold #2</i>	<i>Cylinder manifold #3</i>	<i>Cylinder manifold #4</i>
<i>Position in x</i>	250	425	340	515
<i>Position in y</i>	272,7	272,7	-272,7	-272,7
<i>Position in z</i>	-112,2	-112,2	-112,2	-112,2

78-02-C

The fixing flange of the manifolds and the shape of the manifolds at the point of engagement on the header must be in accordance with the drawing on the side.

Fastening should be done using M8x1.25 class 8.8 screws (stainless steel screws are also allowed), tightening them gradually to a torque of 22 Nm. The length of the mother screw in the head casting is 15 mm. It is convenient to provide an anti-unscrewing washer under each screw head and apply strong threadlocker (green colour) to the threads of the screws.



78-03-P

### 78-22-02 Operating Temperature

During installation, the temperature on each exhaust manifold should be checked using thermocouples. The temperature should be measured approximately 100 mm from the clamping flange of the manifolds to the engine.

The temperatures below are to be considered the maximum attainable at full throttle valve opening, regardless of engine speed. It should be borne in mind that exhaust temperatures generally rise as the percentage of throttle valve opening decreases up to about 40 percent open, then fall again for smaller openings.

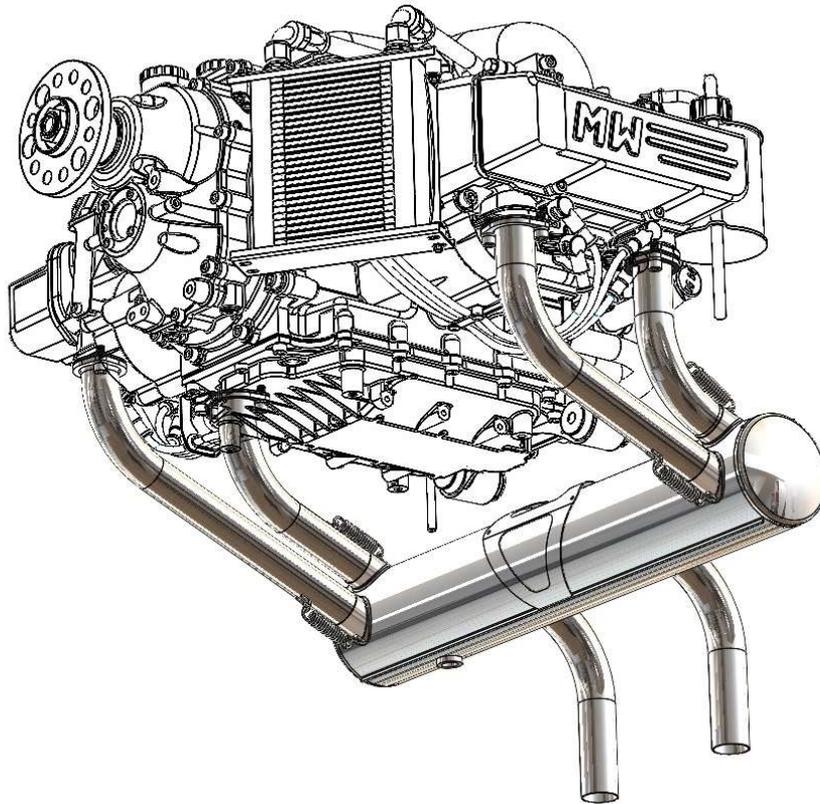
- Maximum constant temperature 850 °C
- Maximum temperature for max 1 minute 920 °C



Exhaust temperatures above the above limit can cause serious engine damage.

### 78-23-00 Standard Manifold and Muffler Installation (EX-m)

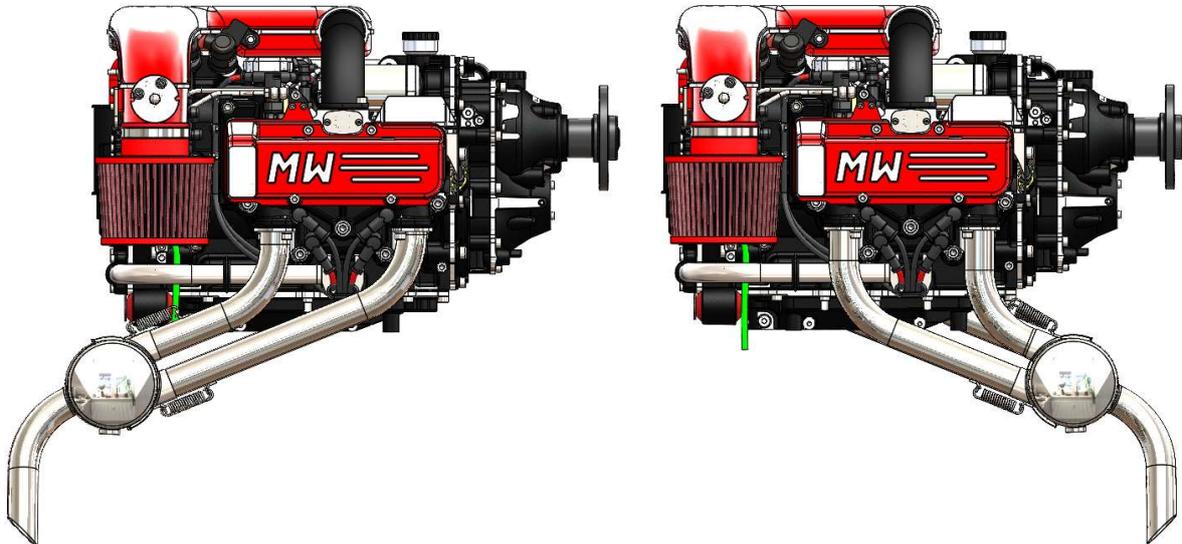
On request, engines can be equipped with an exhaust system (Exhaust module - EX-m), specially designed to lower noise emissions, without penalizing performance too much.



78-04-P

#### 78-23-01 Description

Such a system is suitable for both pulling and pushing applications, being mountable with the muffler facing the rear of the engine or the propeller flange, indifferently: in the latter case, to prevent the propeller blades from interfering with the exhaust terminal, it is necessary to mount a spacer between the propeller and the hub of at least 20 mm thickness.

*78-05-P**78-06-P*

It consists of four exhaust manifolds of different lengths that flow into a cylindrically shaped muffler placed under the powerplant in a recessed, transverse position: the muffler is design to work also as compensation chamber for the pressure waves produced by the succession of phases in the various cylinders and contributes to improving the smooth running of the engine.

The entire exhaust system is made in stainless steel and is mounted in such a way as to avoid distortion of the components as a result of thermal deformation induced by the high operating temperature.

### **78-23-02 Exhaust Component Features**

▪ Manifold weight #1	640 g
▪ Manifold weight #2	430 g
▪ Manifold weight #3	560 g
▪ Manifold weight #4	350 g
▪ Muffler weight	3800 g
▪ Fastener weight	70 g
▪ Total weight	5850 g
▪ Muffler width	656 cm
▪ Sound emission	76 dB

The noise emission value refers to measurements taken at a distance of 5 meters from the engine, at an angle of about 45° to the longitudinal axis of the aircraft, and represents the best value found with the engine at idle speed (1000 rpm).

### **78-23-03 Installation**

#### **Necessary Materials**

1. Torque wrench

2. Pliers
3. 6 mm Allen wrench
4. Hammer with plastic strikers
5. 6 mm flat-blade screwdriver
6. Strong threadlocker

- a.** Number the exhaust manifolds, dividing them according to length, as shown in the figure below.



78-07-P

- b.** Insert the four exhaust manifolds onto the silencer as highlighted in the figure, until they come to a stop at the bottom of their respective housing. To facilitate insertion, use Vaseline if necessary.



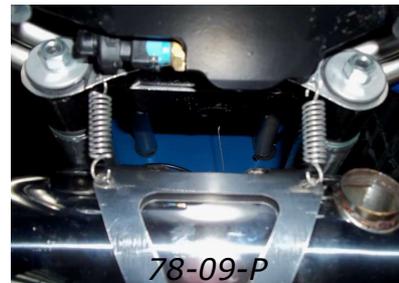
78-08-P

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**c.** Use two pliers [2] to twist the two ends of two springs so that one is rotated relative to the other by about 90°.

**d.** Insert the two springs supporting the silencer into the appropriate holes on the silencer bracket.

- If you want to mount the muffler on the rear of the engine, the springs should be hooked to the holes in the rear engine cover so that the exhaust system hangs on the engine.



- If you want to mount the silencer on the propeller flange side, you must use the support bracket (code T180) to which the springs must be attached. Then the bracket must be fastened to the engine using the two lower gearbox locking screws: fastening in each hole must be done by interposing the annealed copper washers provided between bracket and engine and between bracket and screw head and tightening [1+3] to a torque of 22 Nm.



78-10-P

**e.** Place a gasket (supplied with the exhaust system) between each manifold and the seat in the cylinder heads, taking care to centre it correctly with respect to the holes in the mounting screws.

**f.** Insert the four manifold flanges onto the studs attached to the headers.

**g.** Attach each manifold to the header by screwing on the special nuts provided and interposing the appropriate lock washers: apply a strong threadlocker compound [6] to the threads and screw [3] progressively on the two tightening nuts of each element. Before completing tightening [1+3] to 20 Nm, align the 4 manifolds to the muffler, helping yourself with small hammer blows with plastic knockers [4]. If the assembly is correct, looking at the exhaust system from the propeller side, the silencer should be perfectly horizontal and the outline of the front manifolds should cover that of the rear manifolds: if there are any anomalies, loosen [3] the tightening screws and realign the manifolds.

**h.** Using a screwdriver [5], mount the four tension springs on the attachment hooks so that the spring opening is positioned toward the manifold. In case the tension of the springs is insufficient, bend the attachment lugs on the manifold and muffler.

After the first working cycles, it is necessary to check the tightening [1+3] of the collector retaining screws.

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Before working on the exhaust system, it is necessary to wait for it to cool down for at least 15 minutes after the engine is turned off: failure to observe this warning can result in serious burns and scalds.



Any major gas leakage from the exhaust flange area must be eliminated as it can cause the spark plug wires to burn, resulting in engine malfunction or shutdown.



Small vents from the manifold coupling in the header or muffler are possible, but usually disappear after the first few hours of operation.



Reported performance refers to standard atmosphere conditions (ISA), and is obtained with original MWfly exhaust system and intake filters.



After the first few hours of operation, the exhaust system takes on a yellowish and, locally near the manifold connection in the cylinder head, dark purple colour: this is completely normal and can be attributed to the high temperatures that can be reached by the exhaust system during normal use.

## 78-24-00 Implementation of an Exhaust System

In the case that the EX-m exhaust system is not going to be used, the following notes and recommendations serve as an aid to the aircraft manufacturer or installer, in developing an exhaust system suitable for use.



If the EX-m exhaust system is not used, remapping of the injection control unit is necessary to avoid conditions that could potentially threaten the integrity of the engine.



As a result of using a non-original MWfly exhaust system, the performance of the powertrain may be significantly degraded.

The following recommendations are the result of years of experience: by following them, the results that can be achieved are generally good.

### 78-24-01 Component Characteristics

- |  |                      |
|--|----------------------|
| ▪ Minimum radius of curvature of manifolds     | 50 mm                |
| ▪ Inner diameter of manifolds                  | 35 mm                |
| ▪ Minimum muffler volume                       | 5500 cm <sup>3</sup> |
| ▪ Minimum gas outflow section from the muffler | 1900 mm <sup>2</sup> |
| ▪ Maximum load on each manifold                | 2,5 Kg               |
| ▪ Maximum bending moment on each manifold      | 1 Kgm                |

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- Length of exhaust lights in the header 70 mm



The exhaust system must be designed so that the maximum expected load is not exceeded on each point of attachment. If this is not possible, additional supports must be provided to the system.



Exhaust systems that obstruct or restrict the outflow of combustion gases from the engine raise the operating temperature of the engine and can be the cause of detonation, resulting in severe induced damage.

Preferably use AISI 304 or, better, AISI 420 stainless steel when making the exhaust manifolds and silencer.

The recommended thicknesses for making the various components of the exhaust system are as follows.

- Muffler 0,8 mm
- End tube 1 mm
- Manifolds 1 mm
- Fixing flange 4 mm

It is advisable to realize the attachment of the muffler to the exhaust manifolds by means of tension springs. The mounting load of such springs should be at least 50 N. Arrange on the silencer an attachment point for the lambda sensor with M18x1.5 threading. The probe should be placed after the confluence of the four manifolds in a gas flow area: therefore, avoid placing it near the muffler walls or at stagnation points. The lambda is essential for performing exhaust tuning.

### 78-24-02 Accessories Available

To simplify the construction and installation of non-original exhaust systems, the following accessories are available with their respective order codes.

- Cod. M032 - Traction spring (6 pieces)



78-11-P

- Cod. A117+T245 - Exhaust flange assembly (4 pieces)



78-12-P

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- Cod. G150 – Exhaust Gasket (4 pieces)



78-13-P

- Cod. N329 – Exhaust nut (8pieces)



78-14-P

### 78-24-03 Implementation



Engine-induced vibrations are the main cause of exhaust system failure; therefore, it is essential to contain these vibrations by making a labile exhaust, i.e., not too stiff.

The configuration and shape of the exhaust system are primarily determined by the space available on the aircraft.

The manifolds must be fixed to the engine header by interposing the provided gasket or a suitable sealing compound.



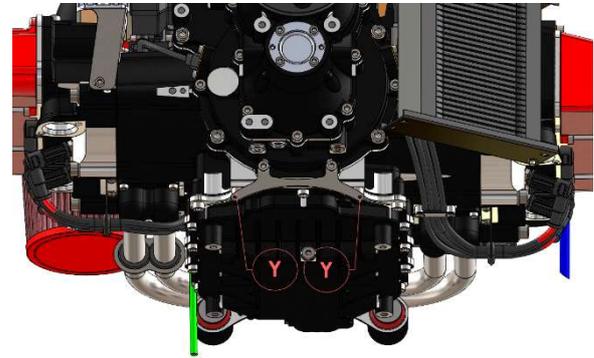
Any gas leaks between the exhaust manifold and the cylinder head are to be avoided, as they could cause the spark plug wires to burn. Frequently check for leaks and the tightness of the retaining screws.

To avoid breakage, the exhaust system must be able to expand upon heating without constraints in opposition: therefore, it is advisable for the muffler to be connected to the exhaust manifolds by springs. The silencer should also be constrained to the engine with an elastic connection: normally, extension springs can be used.

Two holes are provided on the engine for this purpose below the rear attachment points, which can be used to constrain the hook of such springs (points X in fig. 78-13-P). A mounting bracket (item no. T180) is available to tie the muffler to the front of the engine (points Y in fig. 78-18-P). This bracket must be tightened to 22 Nm by means of the two lower screws closing the gearbox to the cylinder block, interposing copper washers, before and after the bracket itself.



78-15-P



78-16-P



It is recommended to fill the spring body with high temperature resistant silicone to increase damping from vibration.



The bonding of the muffler to the engine serves to reduce the bending load on the manifolds and connecting flanges. Failure to provide this restraint is likely to result in rupture of the exhaust manifolds in the area of attachment to the engine.

In cases where the course of the manifolds is not straight, but includes curves in space, the manifolds themselves must incorporate a ball joint: this limits the loads resulting from thermal expansion, and preserves the exhaust from rupture.



**The routing of the exhaust manifolds should be such as to avoid any contact or proximity to the spark plug wires: any deterioration of the spark plug wires due to overheating induced by the exhaust system can cause the engine to suddenly shut down.**



Take care to provide adequate shielding near the passage of cooling hoses and spark plug wires to prevent excessive heating. In any case, there should be no contact of engine parts with the exhaust manifolds.

## 78-25-00 Verification and Validation

In case the EX-m system is used, it is only necessary to make sure that the operating temperature of the exhaust system is not excessively high, a circumstance that would affect its durability. For this purpose, there must be adequate ventilation inside the engine cowling: normally the ventilation produced by the air intakes of the radiator and intake system during advancement is sufficient to contain the operating temperature of the exhaust. If this is not the case, a suitable air intake must be provided on the engine cowling to cool the exhaust system, especially near the junction

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of the manifolds in the cylinder heads and in the side area of the muffler (hottest points).

To determine the operating temperature of exhaust system components, use thermochromic paints, that can indicate the temperature reached through colour variation: this will give a detailed indication of where, if necessary, to intervene to limit the operating temperature. Another way to determine whether the exhaust is working at a suitable temperature is to check its coloration: since the exhaust system is made of stainless steel, if with operation the exhaust tends to dull and take on a yellowish coloration it means that the working temperature is correct; on the contrary, areas of iridescent bluish dark coloration are unequivocally the symptom of an excessive working temperature. However, this second mode of assessment is less rigorous, as it provides qualitative rather than quantitative indications.



To keep the exhaust system efficient, avoid subjecting it to thermal shock: when washing the aircraft, it is a good idea to wait for the hot parts of the engine, and the exhaust system, to return to room temperature.



During the warm-up phase and especially when the exhaust system cools down with the engine off, metallic ticking noises are noticeable: this is perfectly normal, and is caused by the mutual sliding of the hot surfaces of the manifolds and muffler.

In the case of using an exhaust system other than EX-m, in addition to detecting the operating temperature, remapping the ECU and detecting the exhaust gas temperature is necessary: in fact, the exhaust system can also significantly change the engine carburetion and the resulting thermal operating conditions.

The lambda value used for engine tuning is variable, depending on load and rpm, and is optimized on each engine after production during deliberation; similarly, exhaust temperatures are also balanced for each engine after production: this optimization is performed with an EX-m exhaust system, and therefore cannot be considered adequately valid for different exhausts.

ECU remapping can only be performed by MWfly or licensed operators.

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## 79-00-00 LUBRICATION

In the versions that are equipped with a propeller gearbox the lubrication of the gearbox gears is carried out with a specific lubricant, different from that used for the engine oil.



Unless otherwise agreed, the engine is delivered without engine and gearbox oil: the engine must be refilled with oil before starting the engine.

## 79-20-00 Lubrication Circuit



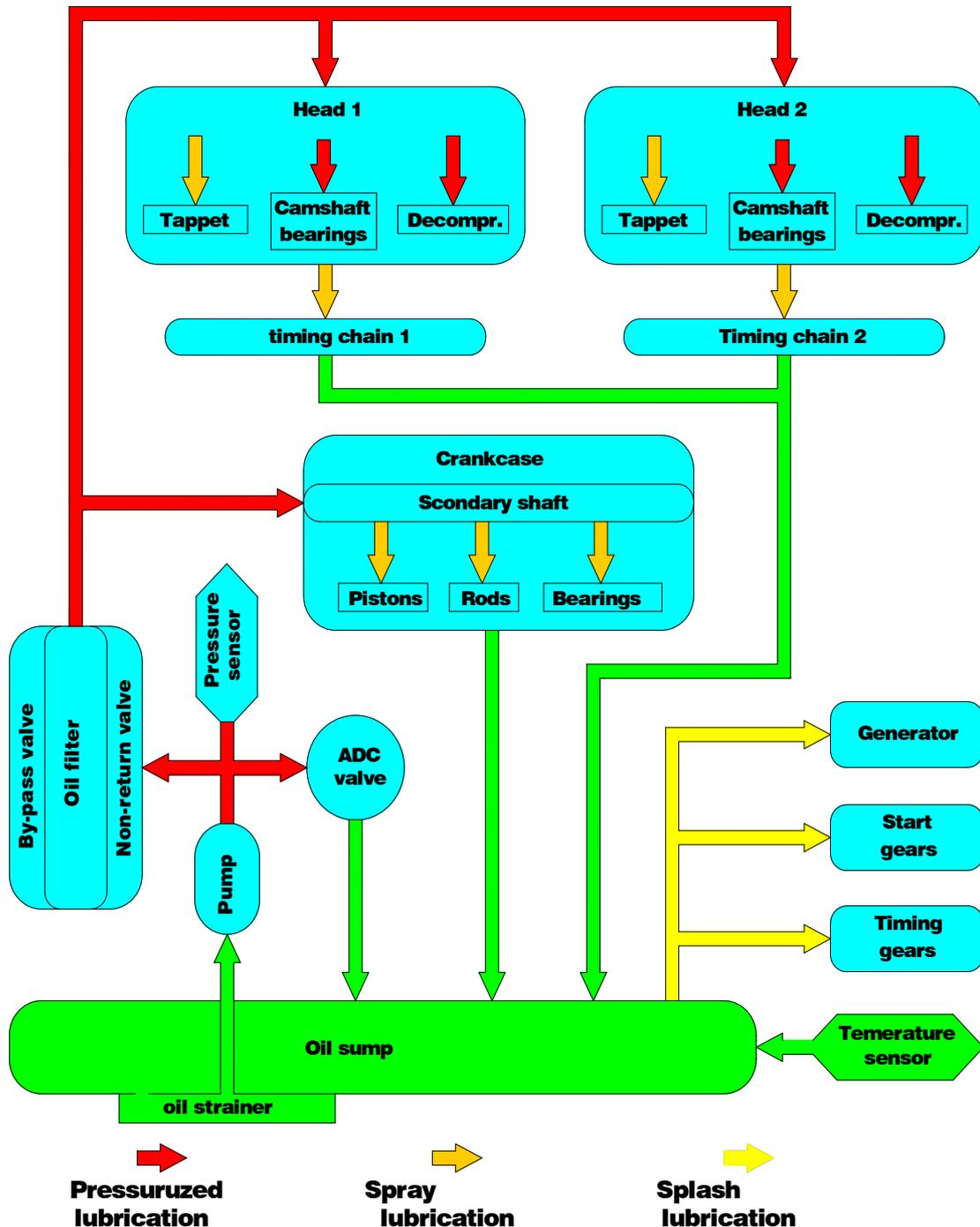
In case of insufficient oil pressure, it is necessary to land as soon as possible, and have the engine overhauled to find the cause of the abnormality and any damage it may have caused.



The lubrication system does not use the pressure pulsations produced by the motion of the pistons to pump oil into the sump, as it is judged to be critical to flight safety.

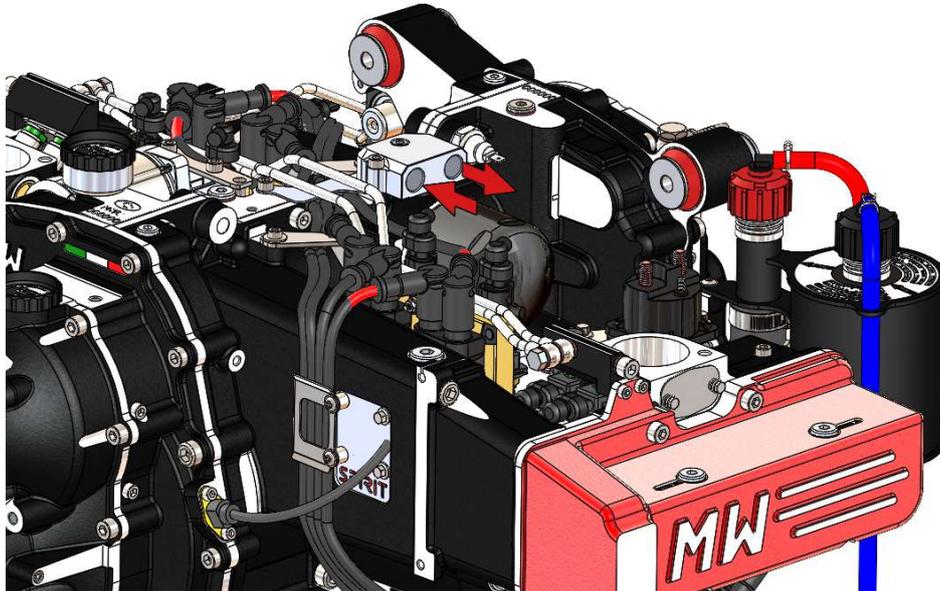
## 79-21-00 Lubrication Scheme

**SPIRIT** engines are equipped with a semi-dry sump lubrication system. The circuit diagram is shown below.



79-01-C

The lubrication pump is of the trochoidal type, and is driven by the secondary shaft, which turns 1.66 times slower than the crankshaft. Oil, drawn from the oil sump through a mesh filter, is sent to the cooler through a collector installed at the top of the crankcase, below the intake system.



79-01-P

Returning from the radiator, the oil enters the cartridge filter after intercepting a pressure relief valve. At the outlet of the oil filter, which is equipped with a check valve and by-pass, lubricant is sent to the two cylinder heads through ducts cut in the upper part of the cylinder block; the lubricant enters the camshafts, and drives the hydraulic decompression devices for starting; the residual oil lubricates the camshaft bearings and thrust washers. From the cylinder head, the oil returns to the sump by gravity through the timing chain compartments. Another part of the lubricant, as it exits the oil filter, is sent under pressure to the crankshaft bearings, connecting rod bearings (which it reaches through ducts inside the crankshaft), secondary shaft bearings and starting system. Surplus oil lubricates the pistons and liners. An anti-skid bulkhead is installed between the cylinder block and the oil sump, which allows the oil to be contained within the sump during more pronounced aircraft manoeuvres.

The engine oil temperature sensor is mounted at the top of bank #1 X, whose data is sent to the injection control unit: for no reason remove or intercept the signal from this sensor. Engine lubricant pressure is measured by a sensor located at the top of bank #2.



In order to circulate effectively in the ducts, the lubrication oil must reach a temperature of about 50 °C: avoid subjecting the engine to high working loads before this temperature is reached.



The oil reaches operating pressure a few seconds after starting: this is completely normal and is not a cause of damage to the engine.

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### 79-22-00 General Characteristics

- |   |                               |
|---|-------------------------------|
| ▪ Maximum engine oil pressure in flight       | 4,5 bar                       |
| ▪ Minimum engine oil pressure in flight       | 1,5 bar                       |
| ▪ Typical engine oil pressure in flight       | 2,5 bar                       |
| ▪ Maximum engine oil temperature in flight    | 130 °C                        |
| ▪ Minimum engine oil temperature in flight    | 50 °C                         |
| ▪ Typical engine oil temperature in flight    | 100 °C                        |
| ▪ Minimum engine oil temperature for starting | -10 °C (with recommended oil) |
| ▪ Rated pump flow rate                        | 26/min @ 3600 rpm             |
| ▪ Pressure setting oil filter by-pass valve   | 1 bar                         |
| ▪ Oil filter weight                           | 280 g                         |

### 78-22-01 Capacity

- |  |           |
|--|-----------|
| ▪ Nominal system quantity (with standard OC-m) | Min 3,1 l |
| ▪ Max  | 3,6 l     |
| ▪ Quantities present in cup with dipstick      | Min 2,4 l |
| ▪ Max  | 2,9 l     |
| ▪ Quantity between min and max level           | 0,50 l    |
| ▪ Contents in the oil filter                   | ~0,20 l   |
| ▪ Contents in OC-m radiator and pipes          | ~0,50 l   |
| ▪ Amount at oil and filter change              | 3 l       |

### 79-23-00 Engine Oil Cooler Installation (OC-m)

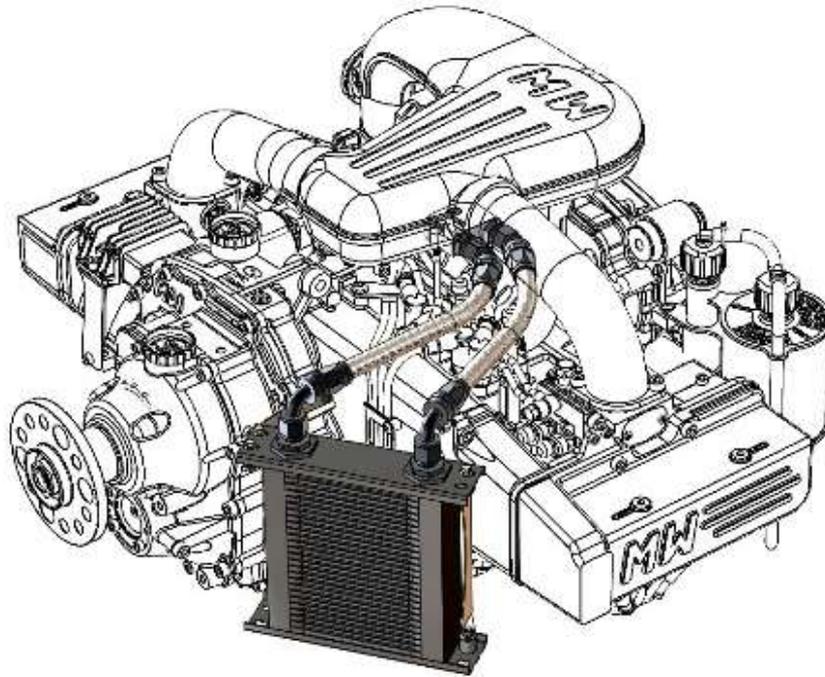
#### 79-23-01 Description

Near the cartridge filter there is provision on the engine for connecting an oil cooler. An oil cooler assembly, called OC-m (Oil Cooler module), is available as an option: the assembly includes the radiator, support bracket, hoses and mounting hardware.



79-02-P

The cooler is located at the front left of the engine, in front of the #2 bank.



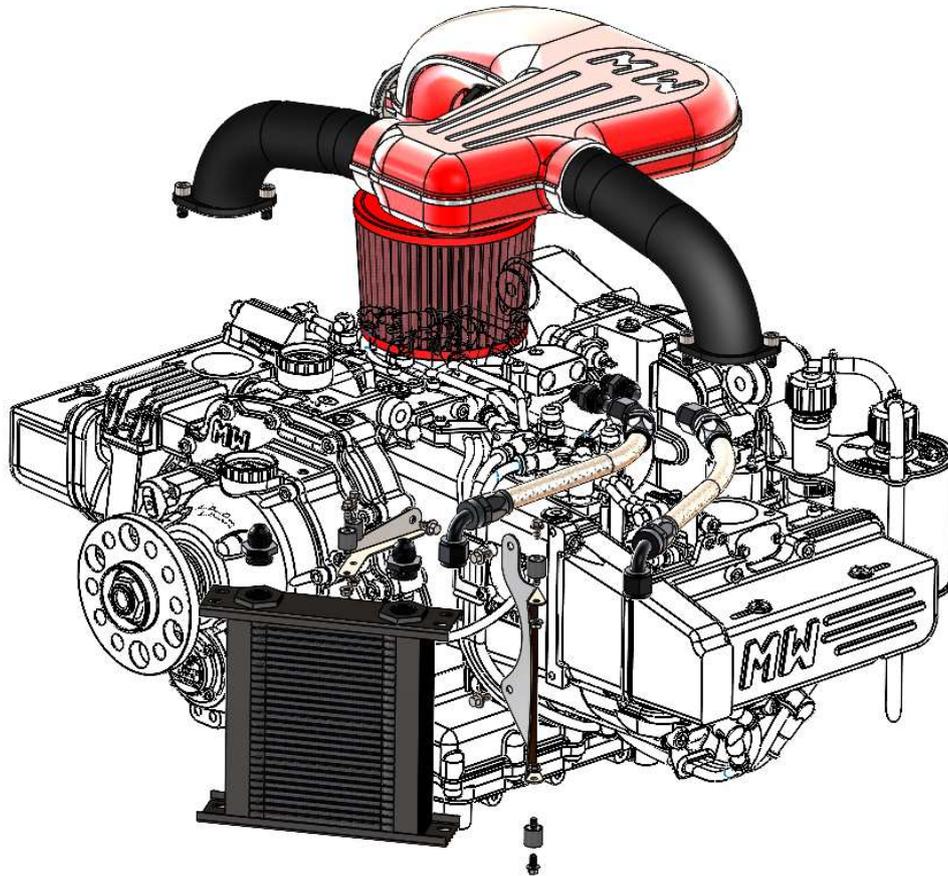
79-03-P

#### 79-23-02 Component Characteristics

▪ Cooler dimensions	210x200x50 mm
▪ Cooler cooling surface	175 cm <sup>2</sup>
▪ Typical cooling flow on the radiator	0,3 m <sup>3</sup> /s
▪ Lubricant tube inner diameter	7,5 mm
▪ Oil quantity in cooler and pipes	~0,43 l
▪ OC-m weight	1,45 Kg

The lubricant is intercepted before entering the cartridge oil filter, sent to the cooler, and then reintroduced into the engine through the appropriately prepared holes.

The connection holes between the engine and oil cooler pipes are in the upper part of the engine, below the airbox: to connect them, the airbox must be removed.



79-04-P

### 79-23-03 Installation

#### Necessary Materials

1. Torque wrench 50 Nm
2. 7/8" socket wrench
3. 8 mm socket
4. 10 mm socket
5. 21 mm socket
6. 27 mm socket
7. Vaseline

Carry out the installation in accordance with the following requirements.

- a.** Remove the intake assembly.
- b.** Screw [5] the adapters to the oil collector, interposing the copper washers provided: tighten [1+5] to 30 Nm.
- c.** Screw [6] the adapters to the cooler, taking care to keep the O-rings provided in place: tighten [1+6] to 30 Nm.
- d.** Attach [3] the supplied silent blocks to the cooler mounting brackets using the appropriate nuts: tighten [1+3] to 5Nm.

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- e.** Attach [4] the main cooler support bracket using the supplied screws, and tighten to [1+4] 10Nm.
- f.** Fasten [4] the secondary bracket using the supplied screw: do not tighten to torque.
- g.** Attach [3] the cooler to the brackets using the supplied screws: tighten [1+3] to 5Nm.
- h.** Tighten [1+4] the secondary bracket to 10Nm.
- i.** Attach [2] the cooler hoses to the oil collector (the 90° bend must remain available for connection to the oil radiator): the shortest must be placed in the forward position (toward the propeller flange); do not tighten.
- j.** Attach [2] the cooler hoses to the cooler itself: do not tighten.
- k.** Arrange the cooler hoses so that they remain flattened below the airbox; then tighten [2] the connecting nipples.
- l.** Reassemble the intake assembly.
- m.** Check on the ground for lubricant leakage: increase tightening if necessary.



During operation, the components of the lubrication circuit heat up to very high temperatures: avoid touching these components before the engine has cooled down for at least 30 minutes since the last start-up.

## 79-24-04 Implementation of the Oil Cooling Circuit

### 79-24-01 Pipes and Fittings

The characteristics of the pipes and fittings of the oil cooler circuit shall be as follows.

- Minimum continuous operating temperature 170 °C
- Minimum continuous operating pressure 10 bar
- Minimum tube inner diameter 7 mm
- Minimum radius of curvature 50 mm
- Minimum pipe inlet length on the fitting 20 mm
- Use hoses suitable for engine oil and anti-ozone, possibly with external metal braid; in any case, change system hoses at least every 2 years.

### 79-24-02 Cooler

The shape, size, and location of the cooler depend mainly on the available space.

- Typical cooler cooling surface ~150 cm<sup>2</sup>
- Typical cooling flow on the cooler 0,3 m<sup>3</sup>/s

Favour positions that minimize the length of the hoses, to reduce pressure drops. The cooler should have a drain plug at the bottom, to be opened when changing engine oil.

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If the cooler is very far from the engine and the hoses are not of adequate diameter, this results in a high pressure drop in the system, which can affect the proper operation of the engine.



Position the radiator and fittings in such a way as to avoid any accidental contact with hot parts of the engine, such as the exhaust system, which could alter its integrity.



During operation, the components of the lubrication circuit heat up to very high temperatures: avoid touching these components before the engine has cooled down for at least 30 minutes since the last start-up.



Under no circumstances use the screws between the crankcase to the gearbox, or air intake to fasten the cooler or an air intake. Failure to do so releases MWfly from all obligations and responsibilities to the user, and will result in automatic revocation of the warranty.

### 79-24-03 *Setting Up*



**Take the utmost care in running the hoses away from heat sources or sharp or abrasive surfaces: if this is not possible, it is necessary to protect the tubes against radiation or contact with suitable material.**

The cooler must be connected to the engine through the collector provided at the top of the crankcase, below the airbox unit (see fig.79-04-P).

As evidenced by the arrows, the supply branch to the radiator is the rear branch (furthest from the propeller flange); the return branch is the front branch.

The threads prepared for connection are M16x1.5.

It is advisable to secure the cooler with anti-vibration mounts (silent blocks).

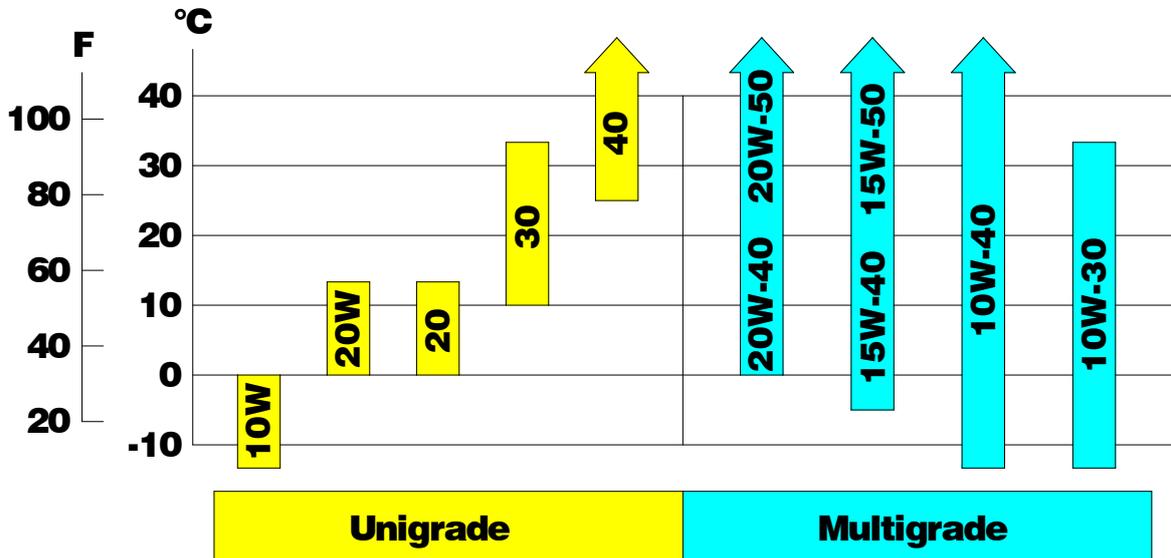


After making the connections between the engine and cooler, check on the ground that there are no lubricant leaks and that the operating pressure is within the prescribed limits.

### 79-25-00 **Recommended Engine Lubricant**

The recommended engine oil for use in temperate climates is SAE 10W40, API specification SH or higher.

When using the engine in particularly cold or hot climates, the optimal viscosity of the oil to be used should be selected based on the average atmospheric temperature of the area of use according to the following table.



79-02-C

The decision to use an oil of a different thermal grade than the prescribed one should be based on the measurement of operating temperatures: in the case of too high lubricant temperatures, oils of a higher thermal grade should be used; in the case of difficulty in reaching the prescribed minimum operating temperature, use oils of a lower thermal grade.

The amount of lubricant contained in the engine is 3.55 litres. In case of using oil cooler, the capacity of the cooler and hydraulic connection and fittings should be added to this quantity.



Insufficient level of engine oil in the sump can cause engine damage.



After the first 10 hours of operation, it is necessary to replace oil and engine oil filter: failure to do so may result in performance degradation and engine damage.

To preserve the integrity of the mechanical components of the engine, it is advisable that the lubricant should not be altered as a result of thermal cycling or oxidation: therefore, engine oil should be replaced at the prescribed intervals even if the engine is not in use or, in the case of particularly severe use (e.g., dusty areas, high operating temperatures, high atmospheric humidity), at shorter periods.



The quality of engine oil has a great influence on the durability and reliability of the engine: replacement at the indicated intervals of filter and oil is therefore an important prerequisite for the integrity of engine operation.

**79-26-00 Lubricant Filling****A**

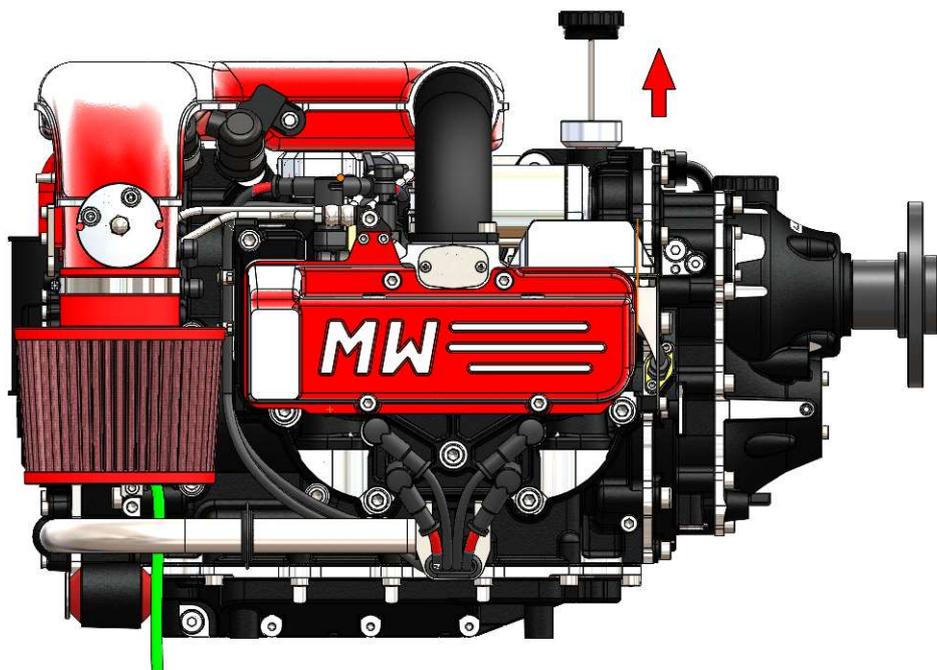
The engine is delivered without engine oil or gearbox oil. Before starting or conducting any kind of test that puts the engine into rotation, it is necessary to refill with the recommended lubricants

Necessary Materials

1. Oil filler cap tightening lever (X283)
2. Paper towels



Engine oil must be introduced by unscrewing [1] the filler cap located on the upper front of the crankcase.



79-05-P

The amount of oil present in oil sump can be checked by means of the dipstick built into the filler cap, on which there is a notch to identify the maximum level; the minimum corresponds to the bottom of the dipstick.



79-06-P

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The difference in oil quantity between the minimum and maximum level is 0.55 litres.

The measurement of the oil level should be made when the engine is cold and waiting at least 5 minutes from any top-up, to allow the oil to flow downward, thus avoiding erroneous readings; the reading should be made taking care to position the aircraft so as to obtain a horizontal lay of the engine.

Level measurement is performed as follows:

- a.** Unscrew [1] the cap by turning counter clockwise.
- b.** Wipe the dipstick of oil using a paper towel [2].
- c.** Reinsert the dipstick into the housing until the cap rests against its seat, without screwing it in.
- d.** Slide the cap with the dipstick back out of the housing.
- e.** Check that the level is between the bottom of the dipstick and the notch; if in doubt about the actual level, use paper towel [2] to check to what level the dipstick is wet with oil.
- f.** Top up if necessary, using oil of the same type. After waiting at least 5 minutes, check the level again.
- g.** Screw the cap back on by hand or with the specific lever [1] (tighten slightly), taking care to check that it has reached the stop.

Periodically also check the seal of the annular gasket (O-ring) located above the cap thread: if there is leakage, replace the gasket with a new one, available for replacement.



Check the oil level in the sump before each flight and top up with lubricant of the same type if necessary.

## 79-27-00 Verification and Validation

Fine-tuning of the lubrication system is done by measuring oil temperature and pressure under the most severe conditions of use. This condition can be identified in the take off and subsequent climb to flight altitude. The condition becomes even more severe in hot weather and, in any case, in the summer season.



Operating the powertrain with engine oil temperatures below the rated operating temperature can cause vapor condensation to form, causing the lubricating properties of the oil to expire.



Using the engine with a non-original engine oil filter can cause serious mechanical damage due to incorrect operating pressure of the lubrication system.

The measurement of these parameters is very easy in case the EM-m instrument is used: in fact, in that case the data appears directly on the instrument, and can also be stored for a more careful and safe evaluation after the flight.

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In case the oil temperature or pressure is not within the operating limits, the thermal grade should be changed, in accordance with the given table. In case the temperature remains high even with an appropriate oil thermal grade, the air flow to the oil cooler should be increased, or a larger cooler should be installed.

In addition to measuring the parameters in the condition described above, it should be verified that along the entire flight envelope, adequate oil pressure is ensured to the engine: if not, try increasing the amount of oil inside the sump, without exceeding one additional liter; if the problem remains, the flight envelope should be limited to ensure stable lubrication conditions. Also make sure that the engine lay is within the reported limits.



The lubrication system is not suitable for aerobatic flight.

It is a good practice to check for oil emulsion build up by unscrewing the lubrication system filler cap. The engine is equipped with an efficient internal ventilation system, which through a labyrinth-like path allows oil vapours to escape from the engine without an excessive amount of oil in suspension. This, in most applications, prevents condensation from forming inside the engine. Where oil emulsions are evident on the plug or on the internal parts of the engine, it is necessary to reduce the flow of fresh air to the oil cooler in a manner that raises the operating temperature of the lubricant while still meeting other operating constraints.

### 79-27-01 *Air Intake Sizing*

It is not possible to provide standard data for sizing the oil cooler air intake, since, as the position on the engine cowl, speed and attitude of the aircraft vary, the amount of air actually passing through the radiator can also vary considerably.

Some sizing criteria are valid for most applications, however, and are summarized below.

- The air intake must be positioned to the right of the propeller (for an observer looking at the aircraft through the propeller) and as close as possible to the plane of rotation of the propeller.
- It is convenient that the height and width dimension of the air intake is about 80% of that of the radiator.
- The most efficient location of the air intake is usually in the lower part of the cowling.
- Make an aluminum sheet metal or fiberglass conveyor between the radiator and the air intake on the engine cowling in such a way as to ensure a fresh and quick supply of air to the radiator. If necessary, the M8x1.25 threaded holes in the underside of the oil pan can be used to attach the air conveyor.
- To improve the efficiency of the radiator, any gaps that may be present between the air intake, conveyor and the radiator itself should be sealed.
- The total area of the air extraction window from the cowling should be at least three times larger than the sum of all air intakes on the cowling, whether cooling, supply or ventilation.

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- It is convenient to conform the brim of the extraction window to resemble a spoiler, to deflect air lapping the cowling and create a vacuum zone.

#### 79-27-02 *Measurement of Engine Oil pressure*

In case the EM-m instrument is not used, a specific sensor must be installed to measure the engine oil pressure. The provision for such a sensor is located on the top of the cylinder block, bank side #2. The threading is 1/4" gas.

#### 79-27-03 *Measurement of Engine Oil Temperature*

Similarly, in the case of the absence of the EM-m instrument, an engine oil temperature sensor must be installed: the provision is on the right side of the oil sump and has an M12x1.5 thread.



The oil temperature sensor preinstalled on the engine supplies the data to the injection system: do not derive the signal for the instrument from this sensor so as not to alter the measured value

#### 79-27-04 *Ambient Temperature - Engine oil Temperature Relation*

It is advisable to perform the verification of the system under the environmental conditions considered "limit" for aircraft operation. The most severe flight conditions for lubrication purposes are obtained by operating as summarized below.

- Maximum ambient operating temperature
- Maximum power applied for maximum allowable time
- Lowest flight speed in relation to applied power

In case the tests are carried out at ambient temperature below the maximum temperature considered permissible, the temperature rise of the lubricant can be calculated from the change in ambient temperature according to the following relation:

$$\Delta T_{oil} = 0,3 * \Delta T_{amb}$$

This means that each degree increase in ambient temperature produces an increase in lubricant temperature of 0.3 °C. For example, running the tests at an ambient temperature of 15 °C, and measuring a maximum lubricant temperature of 93 °C, we can consider that at an ambient temperature of 35 °C, the coolant temperature would rise by about 6 °C to 99 °C.



The maximum attainable temperature under limiting ambient temperature conditions must still be verified in reality. The above report is only valid for a rough verification of the lubrication system.

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## 80-10-00 STARTING

### 80-10-00 Starting System

The starting system consists of an electric starter that acts on a reduction gear, which in turn is engaged on the secondary shaft through a further reduction.

The intermediate gear is equipped with an over-torque clutch, to avoid damage to the gears in case of difficult starting.

The release between the starter and the secondary shaft after starting the engine is ensured by a free wheel, installed inside the last reduction stage.

The starter is controlled by a contactor, which diverts the adequate current required for starting directly from the battery.

### 80-11-00 Component Characteristics

#### 80-11-01 Starter

The starter is attached to the top of the engine at bank #1. The starter results in engine ground. The positive pole of the starter is connected to the start relay contactor by means of a 17 mm<sup>2</sup> (AWG 5) cross-sectional area cable: therefore, no assembly work on the starter is required during installation. The characteristics of this component are as follows.

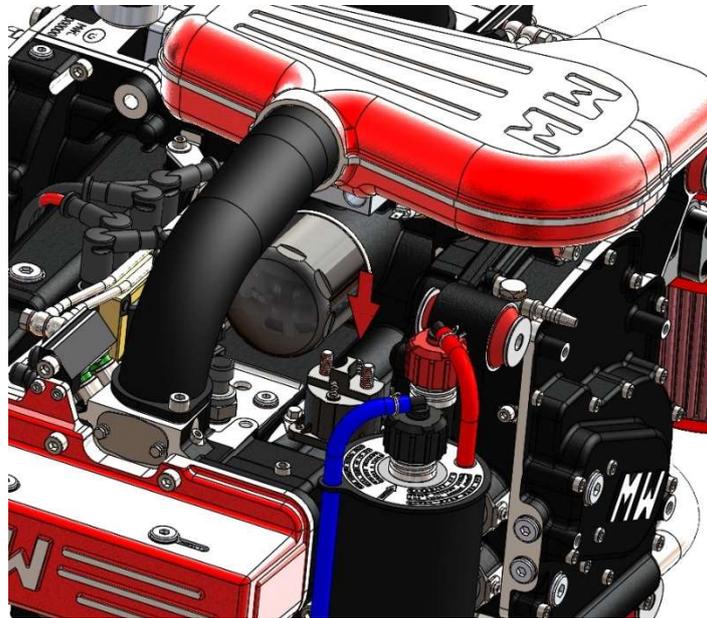
- |                                    |                        |
|------------------------------------|------------------------|
| ▪ Type                             | with permanent magnets |
| ▪ Power rating                     | 0.65 kW                |
| ▪ Rated voltage                    | 12 V                   |
| ▪ Inrush current consumption       | 150 A                  |
| ▪ Maximum temperature for starting | 80 °C                  |
| ▪ Reduction ratio                  | 1÷29.7                 |
| ▪ Engine revs on starting          | 150÷180 rpm            |



Starting is possible even at starter temperatures higher than that indicated, albeit with lower efficiency and higher absorption characteristics.

#### 80-11-02 Start Relay

The start relay is attached to the top of the engine, bank 2 side, and is already connected to the engine wiring.

*80-01-P*

- Rated voltage 12 V
- Current on the exchange
  - max 800 A
  - continuous 100 A
- Operating temperature  $-40 \div 85$  °C
- Weight 200 g
- Exchange terminals 2 for D8 mm eyelet terminal
- Terminal tightening torque 15 Nm

Carry out short start-ups to avoid a overheat the start relay.



The start relay must remain in the upright position, with the terminals facing upward: if the installation requires the start relay to be moved from its original position, comply with this essential requirement.

### *80-11-03 Starting Button*

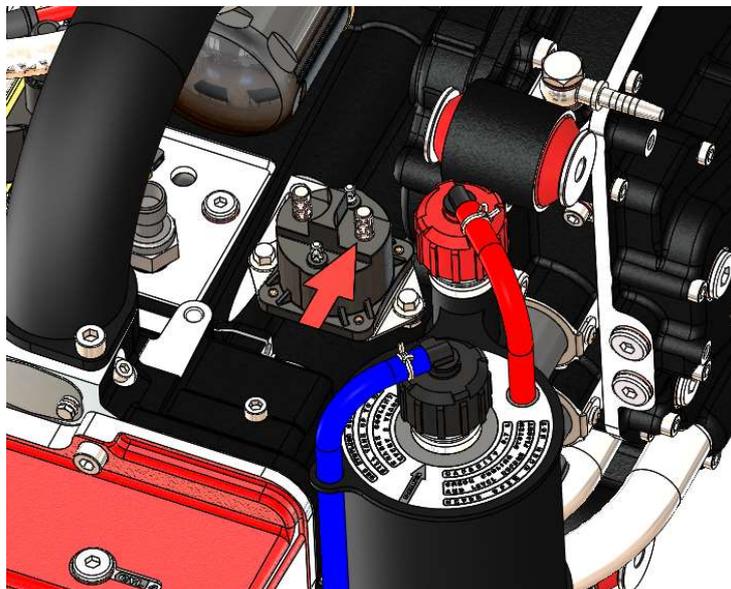
The starting button is responsible for giving consent to the start relay in order to start the engine.

The minimum characteristics of this component should be as follows.

- Switching voltage 12 V
- Switching current 4 A
- Type of arousal momentary
- Number of cycles >50.000
- Operating temperature  $-30 \div 70$  °C

**80-12-00 Electrical Connections**

The engine is delivered with the starter power cable already fitted, and connected to the starter contactor. The cable coming from the terminal named "Start" on the IJ-m should be connected to the second terminal of the start relay, as short as possible and with a cross-section of not less than 17 mm<sup>2</sup> (AWG5). The inrush current for starting can be up to 300 A. The tightening torque of the M8 nut on the contactor should be 15 Nm. Take care to reinstall the safety washer present, which secures against accidental unscrewing. Use D8mm eyelet terminals.



80-02-P



The starting system if used for prolonged periods is prone to overheating. Make starting attempts lasting no more than 10 seconds. Wait at least 30 seconds between starts. If the engine does not start on the third/fourth attempt, it is useless to insist.



In case it is necessary to move the start relay from its original location, it is necessary to reinstall it with the same lie relative to the horizontal to ensure proper operation.



The maximum operating temperature of the starter is 80 °C: avoid exceeding it, so as not to damage the windings and the insulation inside the starter.

After the engine is installed and the engine cowling ventilation vents are made, check the maximum operating temperature of the starter and start relay.

