
# OPERATORS manual for SPIRIT engine

**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.***

# INDEX

# 01 INTRODUCTION

SPIRIT engines have been designed and built using the most modern engine technology, with the aim of obtaining good performance combined with a high level of passive safety. With proper use, they will give you years of enjoyment and reliable service.

Read this manual carefully before using the engine and apply all the safety rules contained therein, as well as those suggested by experience and common sense.

Remember that regular maintenance and a thorough inspection before take-off are essential safety factors.

MWfly will be happy to provide you with further information and all the assistance you may need.

## 01-01 Premise

The purpose of the operating manual is to help familiarize yourself with the operating and safety instructions related to the use of the engines. Before using the engine, it is therefore necessary to understand all the contents of this manual.

If any passage is difficult to understand or in case of doubts, please contact MWfly or an authorized center in writing, requesting clarifications.

For further and more detailed information, please also consult the installation manual, the ordinary maintenance manual and the extraordinary maintenance manual. It is also necessary to summarize the contents of this chapter with what is prescribed and recommended by the aircraft manufacturer as well as suggested by one's own experience.

⚠ **This engine has not received any certification for suitability for aeronautical use.**
**Its use is intended exclusively for experimental or non-certified aircraft, on which a possible engine failure does not compromise flight safety.**

Use the propeller in accordance with the rules and laws in force.

## 01-02 Notes for consultation

The original language of drafting of this document is Italian: Italian is the reference language for any 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*

Subject

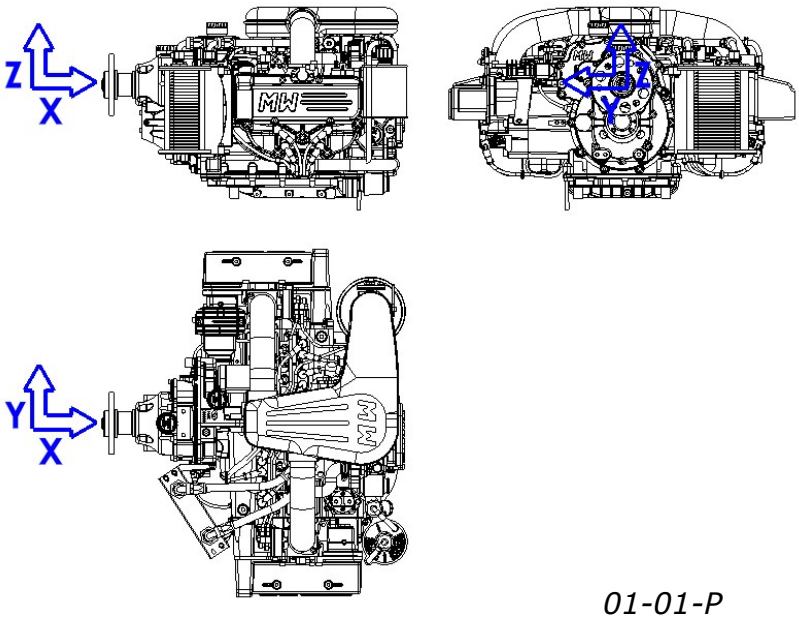
The numbering of the contents of the manual is made up of an alphanumeric code which follows the following criterion.

**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 names of the figures and tables show the chapter number and a progressive number, followed by the letter P for the figures and by the letter C for the tables (e.g. 07-03-P). The measurement system used in the manuals is the technical system (ST); in the tables, the unit of measurement of the quantities represented is indicated enclosed in square brackets [].

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




*01-01-P*

The symbols used in the manuals are as follows.

**Warning: Indicates an instruction which, if ignored, could result in serious personal injury or death.**

Caution: indicates an instruction the non-observance of which can cause serious damage to the propulsor, causing its possible unwanted stop.

INFORMATION: provides additional information useful for completing or fully understanding an instruction.

1., 2., ... This numbering is used to list tools and consumables needed to perform an installation or maintenance operation; it is also used to group in parts lists or engine components highlighted in illustrations.

**a.**, **b.**, ... This numbering is used to list installation or maintenance operations with an inclusion relationship: all actions or options listed must be verified.

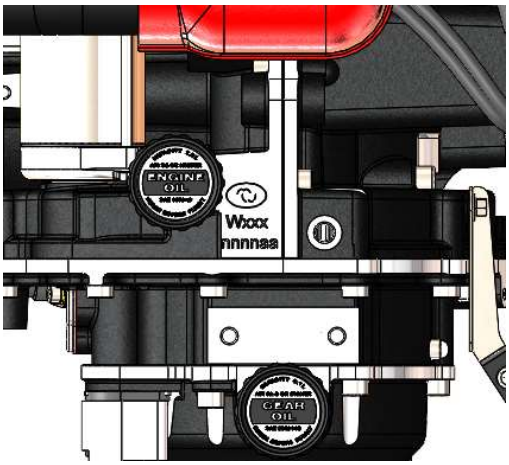
○ This symbol is used to list installation or maintenance operations with an exclusion relationship: only one of the listed actions or options must be checked.

▪ This symbol is used to list general engine characteristics, component specifications, or installation and maintenance options.

(...) A text included in brackets clarifies an aspect, or constitutes an example or a reference to a chapter of the same or of another document.

## 01-03 Identification data

The engine serial number is stamped on the top of the engine, near the gearbox. It consists of the model identification code (check in table 03-01-C of this manual) followed by a six-digit number, the first four of which indicate the serial number and the last two the year of manufacture.




*01-02-P*

Modifying or eliminating this code causes the immediate revocation of the guarantee and releases MWfly from any obligation towards the user.

For each request for information or spare parts it is necessary to indicate the serial number of the engine.

## 01-04 MWfly authorized service centers

For further information on maintenance or spare parts service, please contact the nearest MWfly assistance center (www.mwfly.it).

# 02 SAFETY

## 02-01 Premise

Reading this manual alone is not sufficient to eliminate all dangers associated with the installation and use of the propeller. However, the understanding and application of the information contained therein is essential to use the engine properly and safely, reducing the causes of potential risk.

The information, instructions, description of components and systems, as well as illustrations and technical data contained in this manual are correct at the date of publication of the revision. MWfly keeps its products constantly updated, and any changes to parts of the engine must be understood in this sense, without forcing the user to update what has been purchased: if this eventuality occurs, MWfly, through its distribution and assistance network and through the website www. mwfly.it, will disclose the mandatory nature of any update.

The choice to install and use this engine is entirely subject to the discretion and responsibility of the aircraft manufacturer, assembler and owner: MWfly cannot guarantee the suitability for use of the engine on any specific type of aircraft due to the variety of design and project to which the aircraft themselves are subject; for this reason MWfly is not responsible, nor can it issue any form of guarantee, regarding components, accessories or parts of the aircraft that may be damaged during installation or operation of the engine. The user assumes all risks deriving from the use of the propeller and acknowledges that he is aware of the above.

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.

## 02-02 Security elements

In order to better understand each aspect, it is important to divide the concept of safety into two large subsets: passive safety and active safety.

### *02-02-01 Passive safety elements*

Passive safety concerns engine design and installation criteria. Listed below are some focal points.

- Monolithic connecting rod: reduces the possibility of crankshaft failure, often caused by positioning or tightening errors of the connecting rod cap.
- Pistons machined from solid: greater safety and non-deformability induced by the absence of intrusions from fusion, stresses from molding and the use of an alloy with a low coefficient of thermal expansion.
- Overhead camshaft: makes the use of hydraulic tappets (suitable with pushrod and rocker arm distribution) unnecessary, eliminating the risk of valve breakage in the event of a drop in oil pressure. Furthermore, this solution reduces the

dynamic loads on the distribution control, allowing less friction and less wear on the kinematic mechanism, at the same time improving the precision of the control.

- Gearbox with separate lubrication: increases the reliability of the transmission, reducing the risk of fatigue failure or wear from pitting of the teeth.
- Propeller shaft with front cam flexible coupling: reduces torsional loads on the propeller shaft and on the transmission system, drastically limiting the possibility of fatigue failure of the shaft itself.
- ADC torsional damping system: facilitates starting and stopping the engine, reducing the torsional load on the starting system and transmission components. The ADC system is free from periodic maintenance or adjustments.
- Electronic ignition and injection system: significantly reduces the risk of icing of the intake duct due to the absence of the venturi tube, eliminates the risks deriving from the accumulation of petrol in the carburetor bowls (since they are not present) and i.e. the switching off of the engine during take-off due to forgotten fuel cock closed or aircraft fire in the event of rollover due to fuel leaking from the carburetors; improves engine performance, reducing fuel consumption.
- Pre-installed, high-quality electrical harness: Reduces the risk of electrical failures and difficult setups of home-built systems.
- Pre-installed fuel circuit: the advantage is created by the absence of perishable and heat-sensitive rubber pipes in favor of small-section metal pipes, which are not very sensitive to vibrations and, being non-deformable, do not create a gush effect in the event of break.
- Automatic fuel pump: the command comes from the control unit and provides that, with the engine off, the pump also switches off immediately to prevent fuel leakage in the event of an accident. Furthermore, the pump is of the "non-transparent" type to eliminate the possibility of petrol leaking from the tanks with the pump stopped (and therefore with the engine stopped).
- Entirely liquid cooling: improves the distribution and constancy of temperatures inside the engine and avoids the development of complicated air intakes. Liquid cooling also makes it possible to obtain real performance that is always very close to the rated performance, thanks to the constant thermal regime of the engine.
- Metal coolant passages: eliminates the possibility of detachment and degradation of the fittings.
- Pre-installed thermostat: avoid exposing the engine to useless thermal shocks; allows for shorter warm-up phases.
- Pre-installed expansion tank: reduces the risk of breakage of the hydraulic circuit and consequent overheating of the engine.
- Semi-dry sump: the safety advantage is due to the fact that the presence of oil in the sump is ensured by the force of gravity and by the presence of appropriate containment bulkheads; in the case of a dry sump, on the other hand, a possible vent from the engine gaskets would prevent the oil from returning to the collecting tank, as there is no necessary pressure in the sump.

- Downward Exhaust Manifold Outlet: Reduces the risk of burns or overheating of engine components due to tortuous exhaust routes.
- Certification of production materials and heat treatments.
- Non-destructive testing of details considered vital for safety purposes and their traceability.
- Assembly carried out according to aeronautical standards, with end-of-line verification of the performance of each engine.
- Ease of installation: improves safety as there are fewer pre-flight checks to perform and with excellent accessibility.
- Engine wall mount: reduces the number of threaded couplings between engine and aircraft, to the advantage of safety.
- Complete endoscopic inspection of all the internal components of the engine: this peculiarity allows to keep the operating status of the engine under control, without carrying out any disassembly of parts, nor the disassembly of the engine from the aircraft.

### *02-02-02 Active safety elements*

Active safety concerns the way to use the engine and to carry out its maintenance operations. Below we report some important advice, suggested by common sense and the usual rules of prudence, without however being able to include all the situations or behaviors that constitute opportunities for potential risk.

⚠ **Frequently check engine mounting, flight controls, fuel lines, electrical section and filters.**

⚠ **Never refuel with the risk that it may fall on hot engine components. Always use approved fuel containers, using the utmost caution in transport.**

⚠ **Never pour fuel in an enclosed area, or where fumes could reach the ignition point.**

⚠ **Never run the engine indoors. The exhaust fumes contain carbon monoxide, a particularly poisonous gas which, if inhaled in excessive quantities, rapidly causes loss of consciousness and death.**

⚠ **Never use this engine in unfavorable weather conditions (strong wind, rain, fog, etc.), at high altitudes or in places that may make an emergency landing difficult in the event of a sudden stop of the thruster. The engine is intended for daytime use only.**

**Always carry out a proper inspection before starting the engine: this helps to prevent accidents or damage. In case of doubts about the state of efficiency of the propeller, give up the flight.**

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

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

**This engine is not suitable for aerobatic flying.**

Always keep the engine in perfect working order by following the maintenance table contained in the ordinary maintenance manual and performing the coupons at the envisaged intervals.

Write down any operating anomaly in the engine logbook. Never fly before solving the problem and noting the correction in the logbook.

For the use of the engine and the aircraft, scrupulously comply with all national and local laws and regulations.

Never exceed the maximum number of revolutions foreseen.

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

Never use propellers with a moment of inertia greater than that specified: this eventuality releases MWfly from any liability and from any guarantee obligation.

This powerplant has not received any certification for aeronautical use, nor does it conform to any aeronautical standard. Its use is intended exclusively for experimental or non-certified aircraft, on which a possible engine failure does not compromise flight safety. The user assumes all risks deriving from the use of the propeller and acknowledges that he is aware of the above.

Before starting the engine, make sure that each component of the same is firmly anchored, so as to prevent its involuntary loss in flight.

Never operate the engine with an inadequate amount of oil in the crankcase or reduction gear.

Before switching off the engine, wait a few minutes, essential to make the temperatures of the various components uniform, avoiding unwanted distortions.

The propeller must only be used by trained and qualified users for the purpose, as well as informed on the potential dangers deriving from its use.

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

If there are discrepancies between what is specified in this manual and the legislation in force, proceed according to the most stringent rule.

## 02-03 Warning labels

Some warning labels are applied to the engine, which show the top-ups to be made before take-off, and other information regarding the operation and characteristics of the engine. These labels are in English: below we report their meaning and the area of application on the engine.

### *02-03-01 Engine oil cap*


*02-01-P*

- CAPACITY 2.85L - Capacity 2.85 liters
- API SG OR HIGHER – Lubricant specification API SG or higher (identifies lubricant quality according to American Petroleum Institute specifications)
- ENGINE OIL – Engine oil
- SAE 10W/40 – Thermal degree of the lubricant 10W/40 (for the choice of the most suitable oil according to the climatic areas, consult the installation manual)
- CHECK BEFORE FLIGHT – Check the level before each flight

## *02-03-02 Gearbox oil cap*


*02-02-P*

- CAPACITY 0.4L – Capacity 0.4 liters
- API GL-5 OR HIGHER – Lubricant specification API GL-5 or higher (identifies lubricant quality according to American Petroleum Institute specifications)
- GEAR OIL – Transmission oil
- SAE 80W/90 – Thermal grade of lubricant 80W/90
- CHECK BEFORE FLIGHT – Check the level before each flight

*This warning label is not present on versions without gearbox.*

## *02-03-03 Gearbox oil level arrow*

*02-03-P*

The arrows on the side of the gearbox identify the gearbox oil levels screw.

## *02-03-04 Adapter*

The label is located on the top of the gearbox and bears the name of the torsional damping system adopted on engines of the AeroPower series (B.5.5).


*02-04-P*

- ACTIVE DAMPING CONTROL – Active control of torsional vibrations on starting and stopping.

The label is not present on versions without gearbox.

## *02-03-05 Governor*

Engines with reduction gear can be equipped with constant speed governor with electro-hydraulic operation (A.15.1.2.). In this case the presence of the governor is indicated by the sticker positioned on the pump cover in the front part of the reducer.


*02-05-P*

- PROP GOVERNOR INSIDE – Internally mounted propeller governor
- FULLY INTEGRATED ELECTRO-HYDRAULIC – Integrated electro-hydraulic system

## *02-03-06 Expansion tank*


*02-06-P*

- USE ETHYLENE GLYCOL ONLY – Use only ethylene glycol (avoid using propylene glycol or unmixed water)
- FILL TANK UP TO 2/3 – Fill the expansion vessel to 2/3 of its capacity
- CHANGE COOLANT EVERY 2 YEARS – Replace the coolant every 2 years
- RESERVOIR – Indicates the closure cap of the expansion vessel (not pressurized)
- PRESSURIZED – Indicates the closing cap of the cooling system (pressurized)
- CAPACITY 0,7 L – Capacity of the expansion vessel 0.7 liters
- CHECK COOLING SYSTEM AND LEVEL BEFORE FLIGHT – Check the cooling system and coolant level before each flight
- NEVER OPEN WHEN HOT – Do not open when the engine is hot (referring to the pressurized cap)

## *02-03-07 Water circuit arrow*

*02-07-P*

The arrows are placed near the water pump inlet and outlet manifolds, and identify the direction of flow in the manifolds themselves. In particular, the lower manifold sends the coolant to the radiator, the upper manifold receives the coolant from the radiator to send it to the pump. Other arrows are placed near the holes for the cab heating circuit to indicate the direction of flow.

## *02-03-08 Head cover*

*02-08-P*

The stickers are placed on the upper part of the cylinder head covers, and identify the cylinders according to the numbering shown in section 4.3.

- CYL1 – cylinder number 1
- CYL2 – cylinder number 2
- CYL3 – cylinder number 3
- CYL4 – cylinder number4

## *02-03-09 Fuel circuit arrow*

*02-09-P*

The arrows are placed on the fuel shunt, and identify the direction of the fuel flow at the inlet and outlet of the shunt. In particular, the lowest port identifies the pressurized fuel inlet to the shunt, the highest port identifies the fuel outlet from the shunt for return to the tanks.

## 02-04 Use of technical documentation

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

The information provided in the following manuals report procedures and checks that can be implemented by qualified professionals working in the sector under normal operating conditions.

- DMA.E10 - Installation manual: contains the information necessary for the correct installation of the engine.
- DMB.E10 - Operating manual: contains the information required for the intended use of the engine.
- DMC.E10 - Routine Maintenance Manual: Contains information necessary to properly perform scheduled maintenance.
- DMD.E10 - Extraordinary maintenance manual: contains the information necessary for carrying out unscheduled maintenance, i.e. determined by breakdowns.
- DME.E10 - Illustrated spare parts catalogue: contains the list of spare parts and accessories provided.
- DSL.E10 - Service letter: contains information intended to improve the product or the use of the same.
- DSB.E10 - Service bulletin: reports the replacements, checks or warnings to be applied by the indicated deadline.

The illustrations in this manual do not represent the details of the propeller in detail, 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 documentation that may be necessary is in any case available at MWfly authorized assistance centers.

# 03 ENGINE DESCRIPTION

## 03-01 General characteristics

- 4-cycle stroke
- 4 boxer cylinders
- Distribution with single overhead camshaft (SOHC), chain and gear drive, bucket tappets with upper register pad, 2 valves per cylinder
- Liquid cooling system with double involute pump, expansion vessel and integrated thermostat, circulation ducts in stainless steel
- Forced lubrication system with trochoidal pump, semi-dry sump with integrated ducts
- Electronic ignition mapped to inductive discharge, with thermal and altimetric adjustment
- Mapped electronic double injection power supply, with thermal and altimetric adjustment
- CAN bus system for data transmission
- Fuel system with electric fuel pump with automatic safety control and auxiliary pump, pressurized circuit with steel pipes and integrated pressure regulator
- Integrated reduction unit with separate splash lubrication, helical tooth gears, predisposition for hydraulic propeller pitch control (not present in versions without reduction unit)
- Front cam dissipative torsional damping system with return springs
- ADC system (Active Damping Control) antikickback in starting and stopping
- Starting system with electric starter, integrated contactor, oil-centrifugal decompressor and safety clutch
- Charging system with oil-cooled permanent magnet generator and external current regulator

## 03-02 Versions available

The direction of rotation of each engine version (both with reduction gear 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 makes a right rotation (right "R" engine), a propeller that moves in an anticlockwise direction makes a left rotation (left "L" engine). Each engine model can use either pulling or pushing propellers.

The following table summarizes the main characteristics of **SPIRIT** engine.

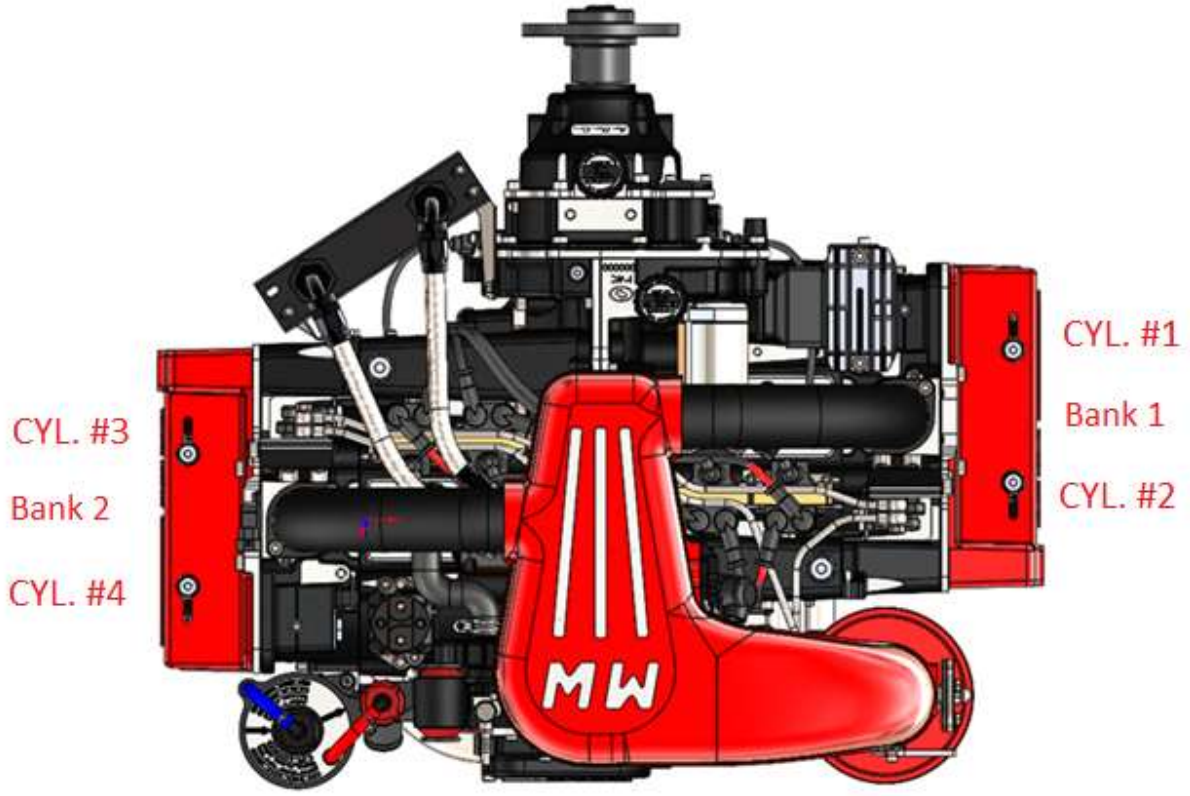
| Name | Code | Max power [hp] | Max power continuous [hp] | Maximum engine revolutions [rpm] | Max propeller shaft rpm [rpm] |
|---|---|---|---|---|---|
| *Spirit 100 Direct L/R* | W011/W012 | 100 | 100 | 3500 | 3500 |
| *Spirit 115 Direct L/R* | W013/W014 | 115 | 115 | 3500 | 3500 |
| *Spirit 135 Direct L/R* | W017/W018 | 135 | 120 | 4750 | 4750 |
| *Spirit 160 Direct L/R* | W023/W024 | 160 | 142 | 4750 | 4750 |
| *Spirit 122 PSRU L/R* | W015/W016 | 122 | 110 | 4250 | 2450 |
| *Spirit 135 PSRU L/R* | W019/W020 | 135 | 115 | 4750 | 2425 |
| *Spirit 140 PSRU L/R* | W021/W022 | 140 | 125 | 4250 | 2450 |
| *Spirit 160 PSRU L/R* | W025/W026 | 160 | 137 | 4750 | 2425 |

*03-01-C*

In addition to the ones listed above, further versions can be made upon customer request: the complete list is available in a separate document.

## 03-03 Name of cylinders and location of parts

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




*03-01-P*

To identify and know the location of the various engine components, refer to the installation manual.

# 04 TECHNICAL FEATURES

Unless otherwise specified, the following data refers to all versions.

## 04-01 Intended use

The engines of the **SPIRIT** series have been designed and built to equip ULM, Experimental or LSA category aircraft with two or three axles, with power required in compliance with the power supplied by the engine.

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

**For safe use of the engine it is necessary to respect, in addition to the operating limits, the maintenance deadlines indicated in the scheduled maintenance programme.**

In no way can the warranty and the safety specifications be extended to uses other than those mentioned above. MWfly declines all responsibility for damages or injuries caused to people or things deriving from a failure or sudden stop of the propeller. Improper use of the propeller causes the immediate revocation of the guarantee and releases MWfly from any further obligation towards the user.

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

To safeguard the integrity of the propeller it is necessary to install and use it properly. It is therefore important to check, using the instrumentation, that the operating limits are respected in all operating conditions.

## 04-02 Performance

The values and graphs in this chapter show performances referred to a temperature of 15 °C, at sea level (1013 mbar), and relative humidity equal to 0% (ISA-International Standard Atmosphere conditions).

| Spirit Skyline versions | | | | |
|---|---|---|---|---|
| **Power [hp (kW)]** | 100 Direct R/L | 135 Direct R/L | 122 PSRU R/L | 140 PSRU R/L |
| *At take-off max 5 minutes @rpm* | 100 (73,5) @3400 | 135 (99,3) @4700 | 122 (89,7) @4200 | 140 (103) @4200 |
| *Continuous maximum @map* | 100 (73,5) @29,8 | 120 (88,3) 28,5 | 110 (80,9) 28,5 | 125 (91,9) 28,5 |

*04-01-C*

| Spirit Redline versions | | | | |
|---|---|---|---|---|
| **Power [hp (kW)]** | 115 Direct R/L | 160 Direct R/L | 135 PSRU R/L | 160 PSRU R/L |
| *At take-off max 5 minutes @rpm* | 115 (84,6) @3400 | 160 (117,7) @4700 | 135 (99,3) @4700 | 160 (117,7) @4700 |
| *Continuous maximum @map* | 115 (84,6) @29,8 | 142 (104,4) 28,5 | 115 (84,6) 28,5 | 137 (100,8) 28,5 |

*04-02-C*

The use of the maximum power is limited to 5 minutes. The maximum continuous power is defined as a function of the vacuum in the manifold (MAP).

In flight, favor power settings with high rpm and low MAP value, compliant with the continuous maximum power curve.

Using the engine for prolonged periods beyond the maximum continuous power can cause serious damage and sudden shutdown.

The following paragraphs show the performance summary graphs for each engine model.

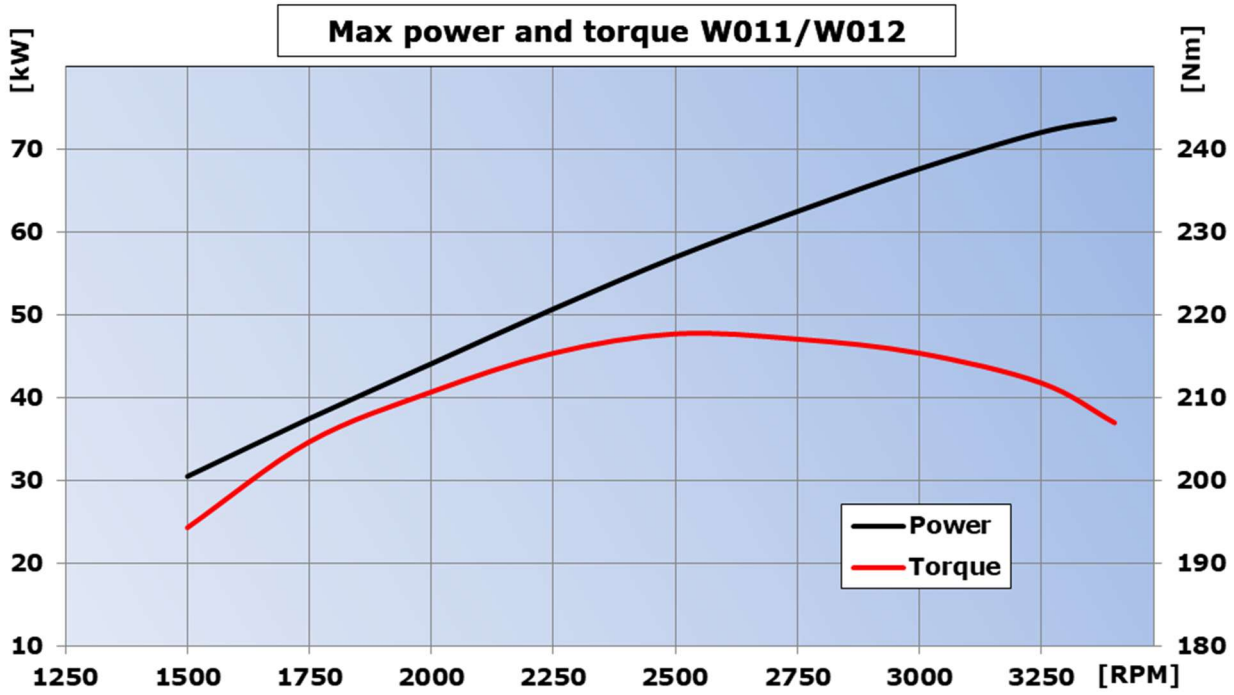
- Power/rpm and torque/rpm graph as a function of rpm: it expresses the maximum torque and power obtainable from the engine (at full throttle opening) as a function of the rotation speed.
- Graph of required power/available power: this graph represents the field of use of the engine (area enclosed by the two curves), reporting the power expressed by the engine (maximum power) and the power required at each speed to keep a pitch propeller rotating fixed, in the hypothesis that the mounted propeller can reach and not exceed the maximum foreseen revolutions in flight.

- Power/rpm graph at constant MAP: each curve refers to a vacuum value in the intake manifold (MAP), expressed in inches of mercury (inHg) and shows the power obtainable as a function of the engine speed.
- Power/MAP graph at constant rpm: each curve refers to an engine rotation speed and shows the power obtainable as a function of the vacuum in the intake manifold (MAP).

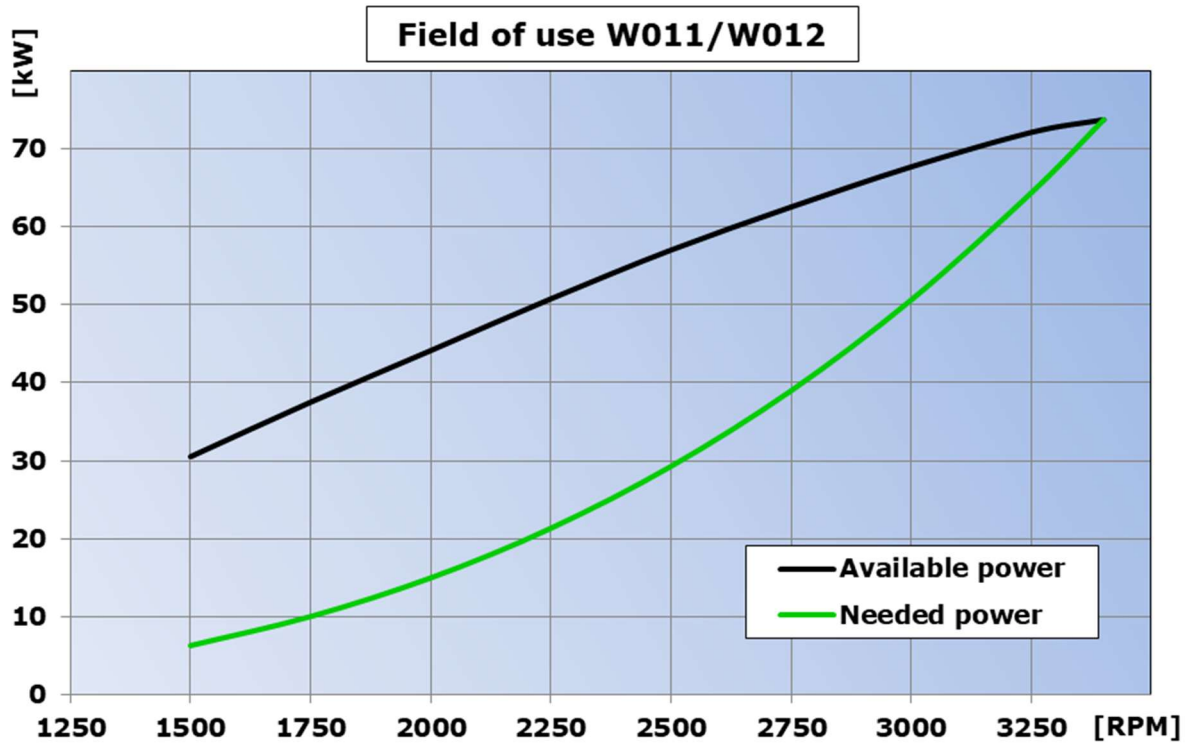
The maximum MAP value shown in the graphs is the maximum obtainable at full throttle opening with a barometric pressure of 1013 mbar.

Deviations from the curves shown are possible in the amount of 5%, as a result of dimensional and assembly tolerances.

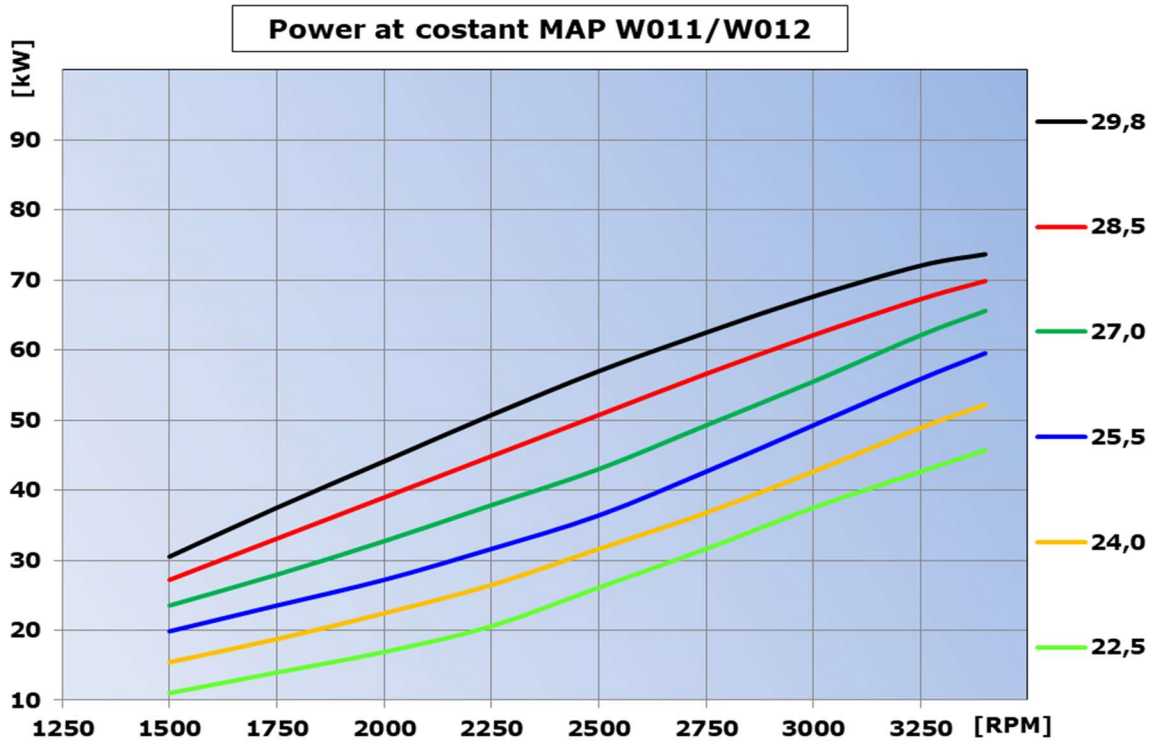
*04-02-01 Spirit 100 Direct R/L*



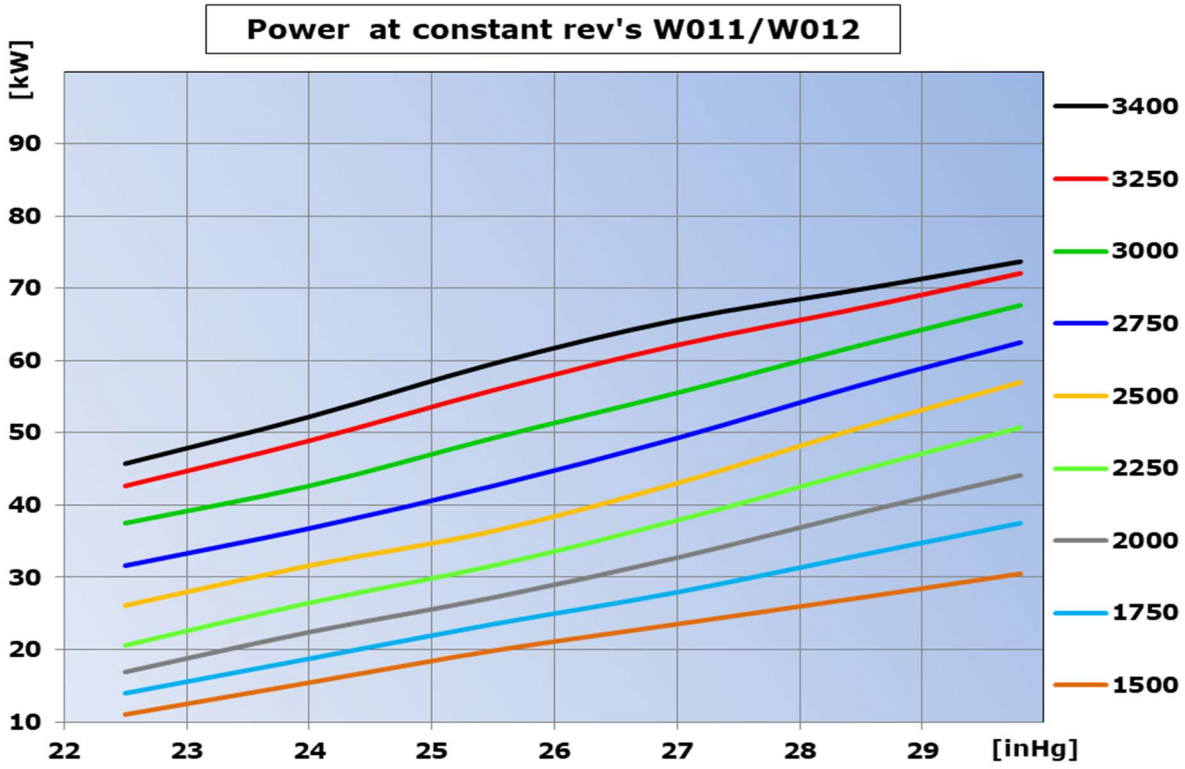

*04-03-C*




*04-04-C*

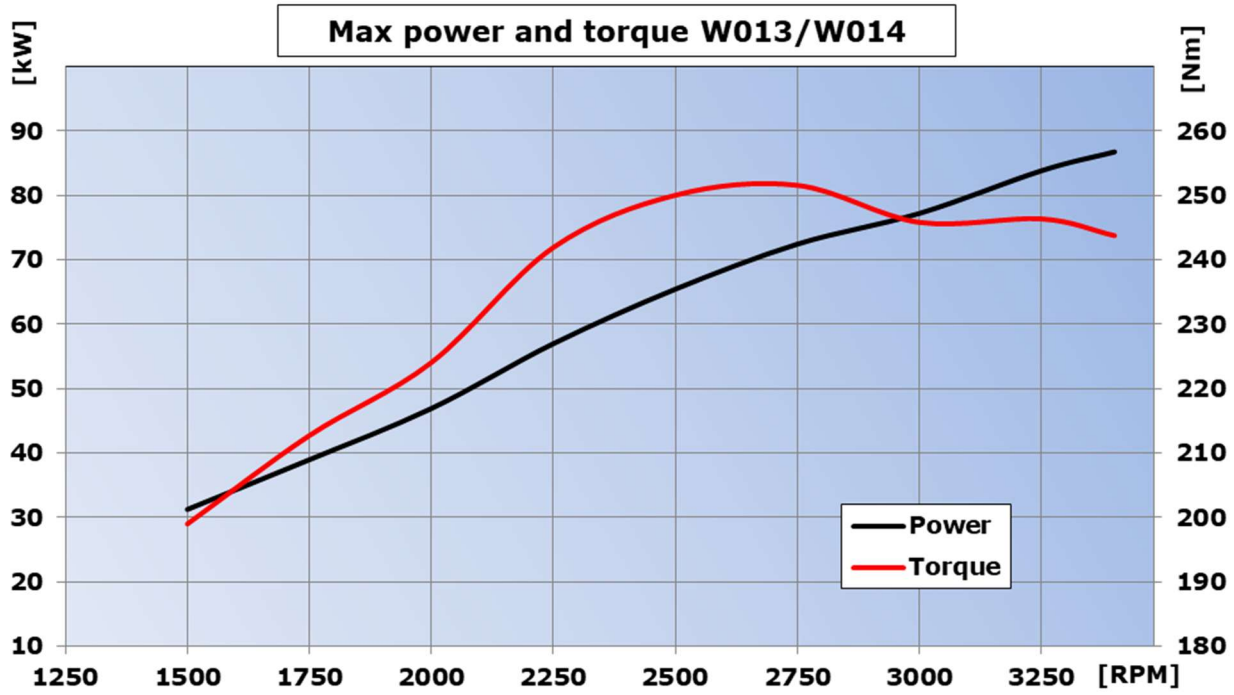

Power at costant MAP W011/W012
[kW]
90
80
70
60
50
40
30
20
10
1250
1500
1750
2000
2250
2500
2750
3000
3250
[RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-05-C*

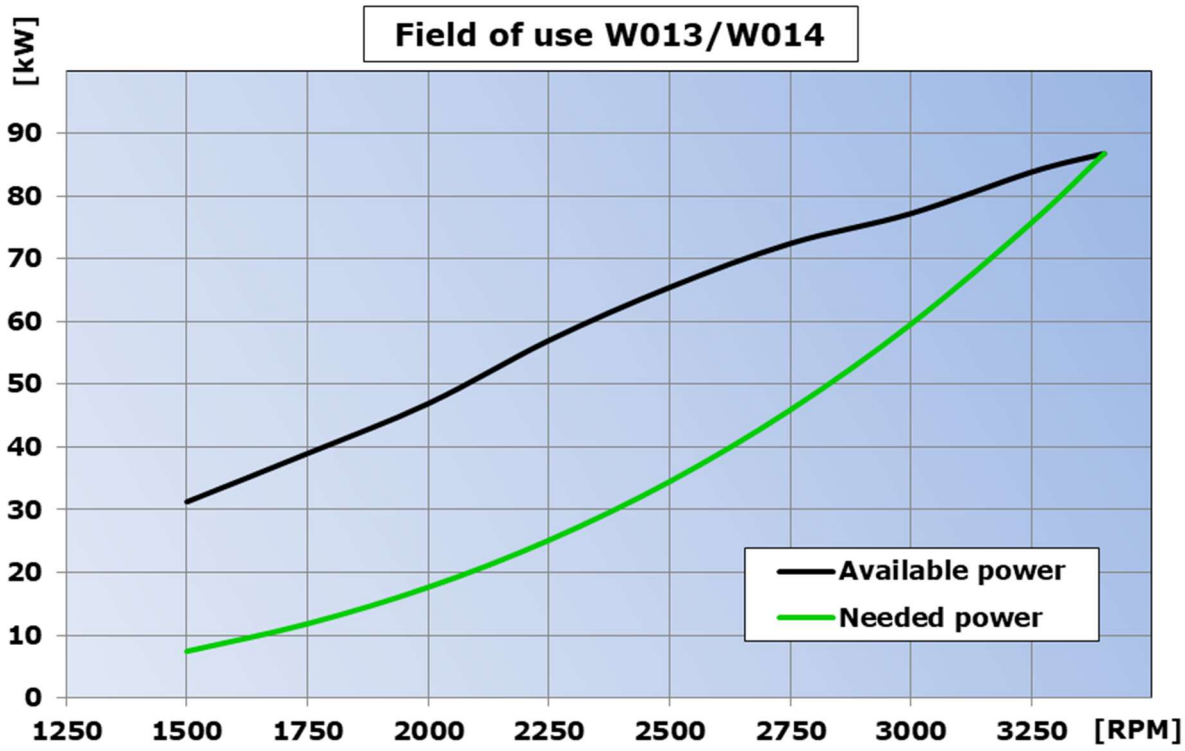

Power at constant rev's W011/W012
[kW]
90
80
70
60
50
40
30
20
10
22
23
24
25
26
27
28
29
[inHg]
3400
3250
3000
2750
2500
2250
2000
1750
1500

*04-06-C*

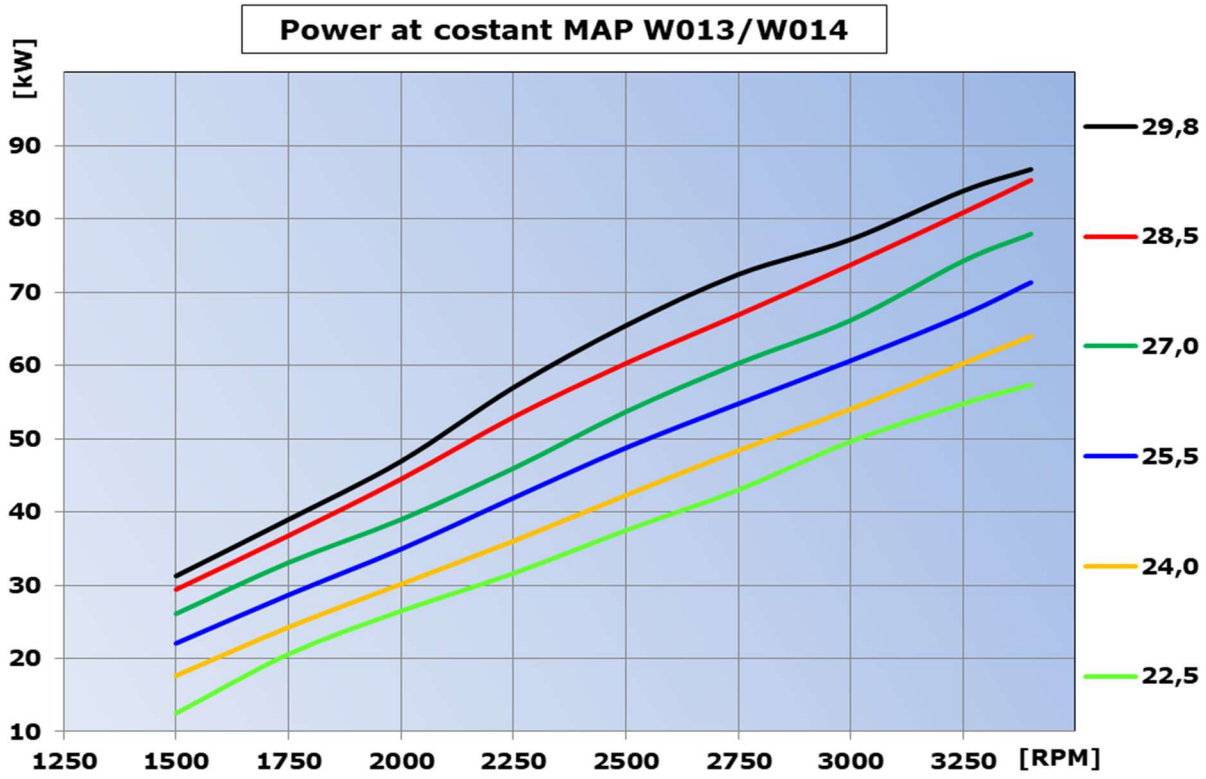
*04-02-02 Spirit 115 Direct R/L*



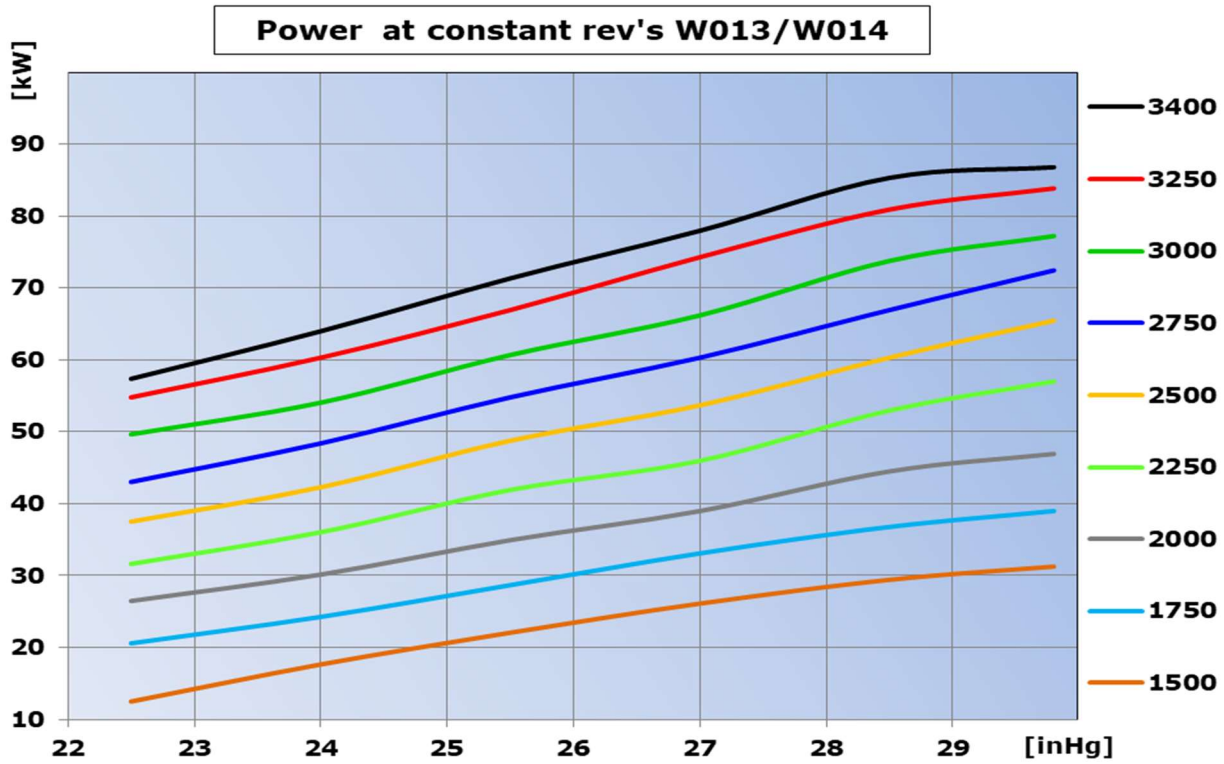

*04-07-C*




*04-08-C*

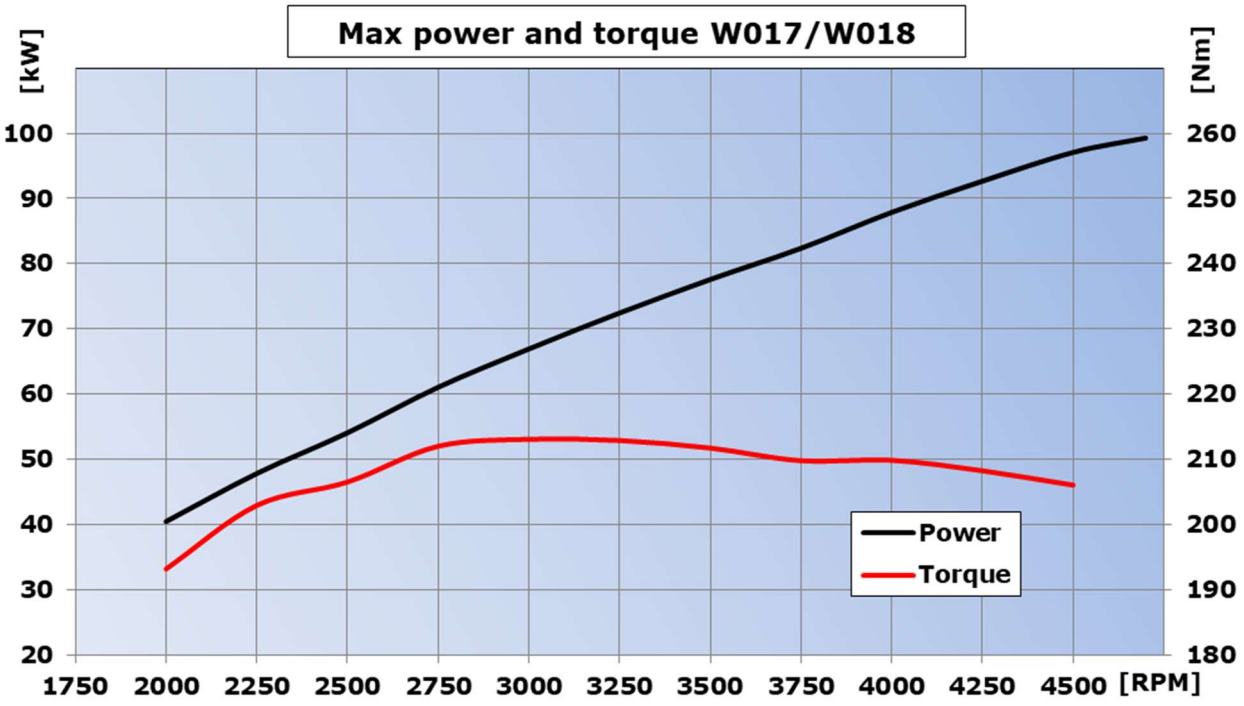

Power at costant MAP W013/W014
[kW]
90
80
70
60
50
40
30
20
10
1250
1500
1750
2000
2250
2500
2750
3000
3250
[RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-09-C*

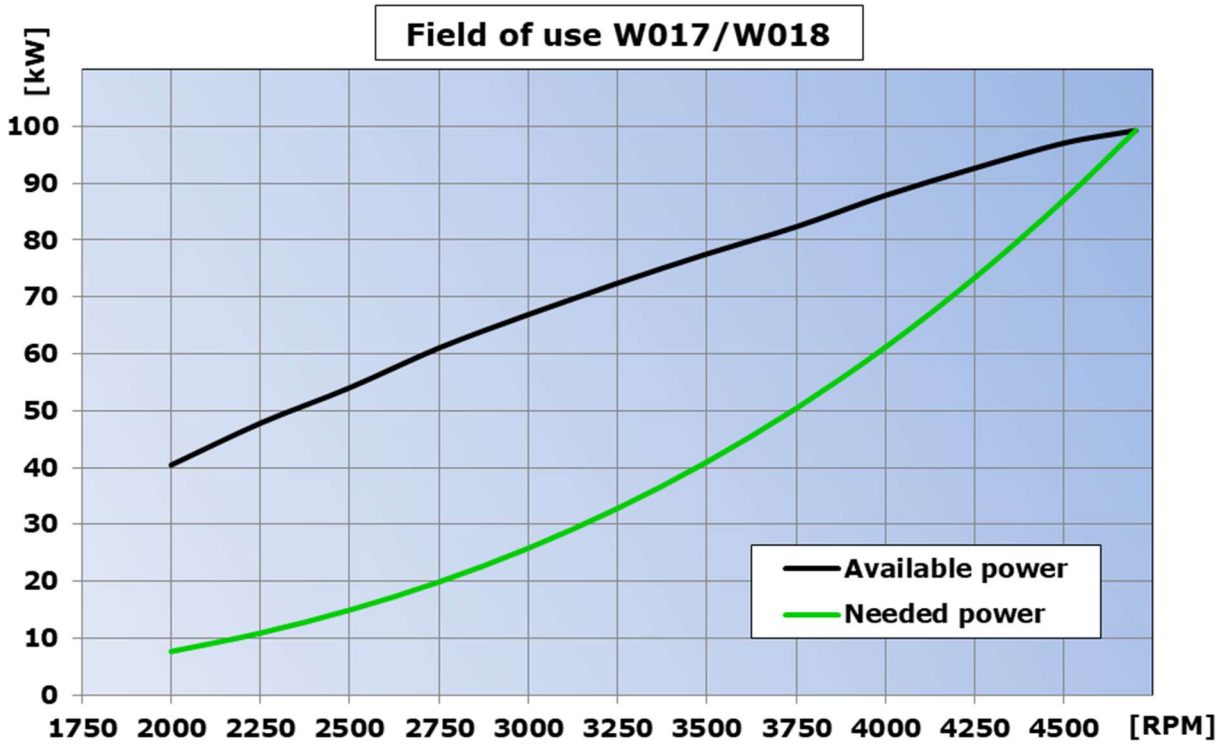

Power at constant rev's W013/W014
[kW]
90
80
70
60
50
40
30
20
10
22
23
24
25
26
27
28
29
[inHg]
3400
3250
3000
2750
2500
2250
2000
1750
1500

*04-10-C*

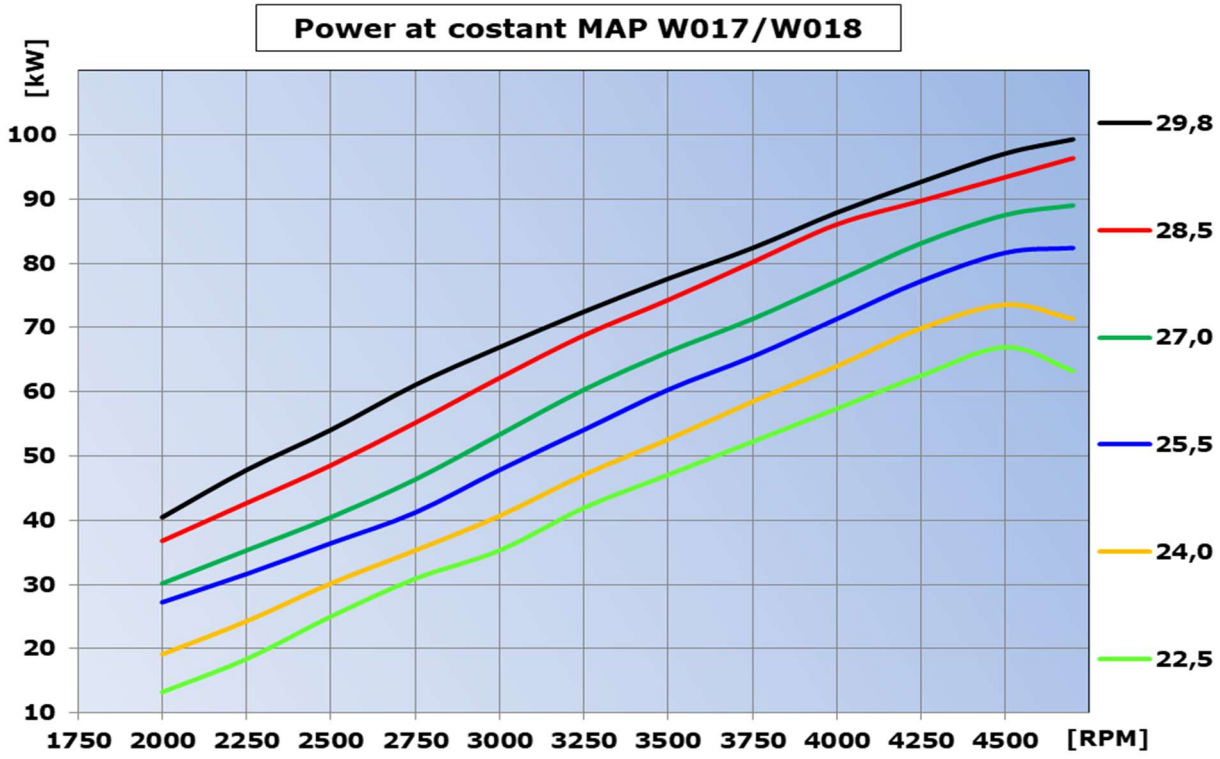
*04-02-03 Spirit 135 Direct R/L*



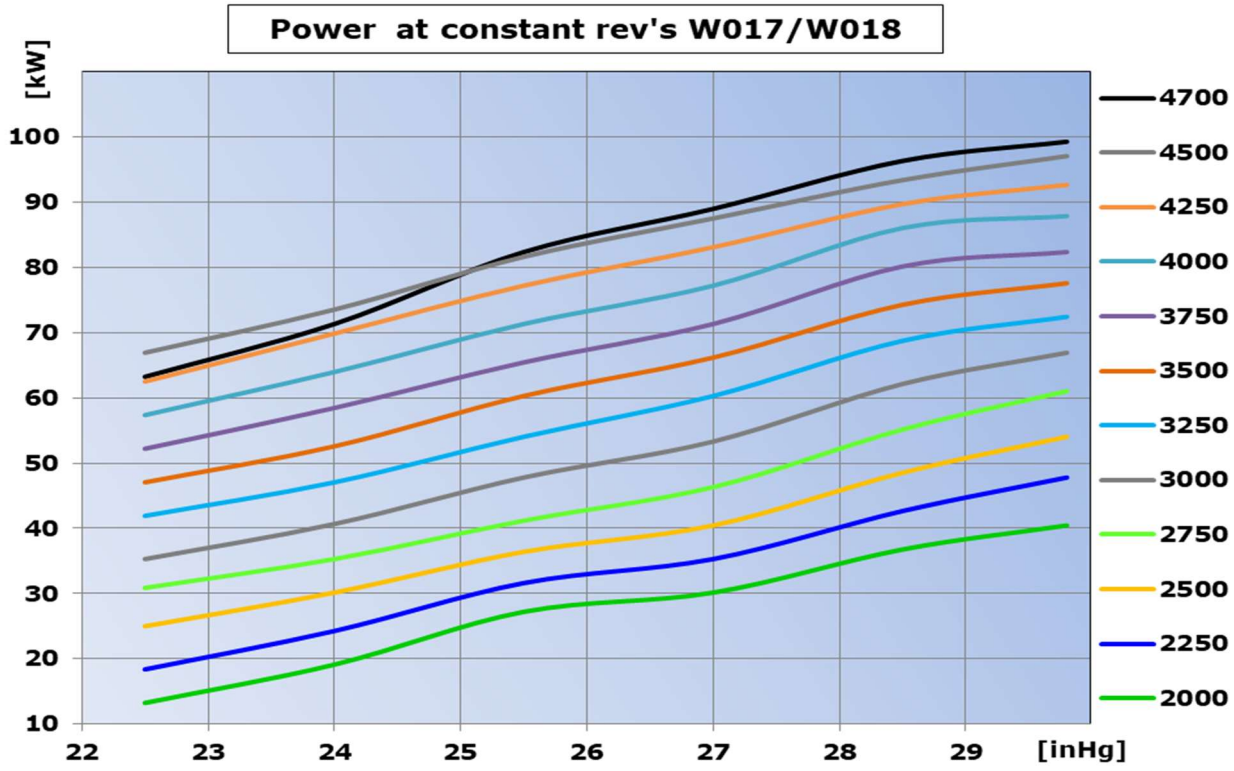

*04-11-C*




*04-12-C*

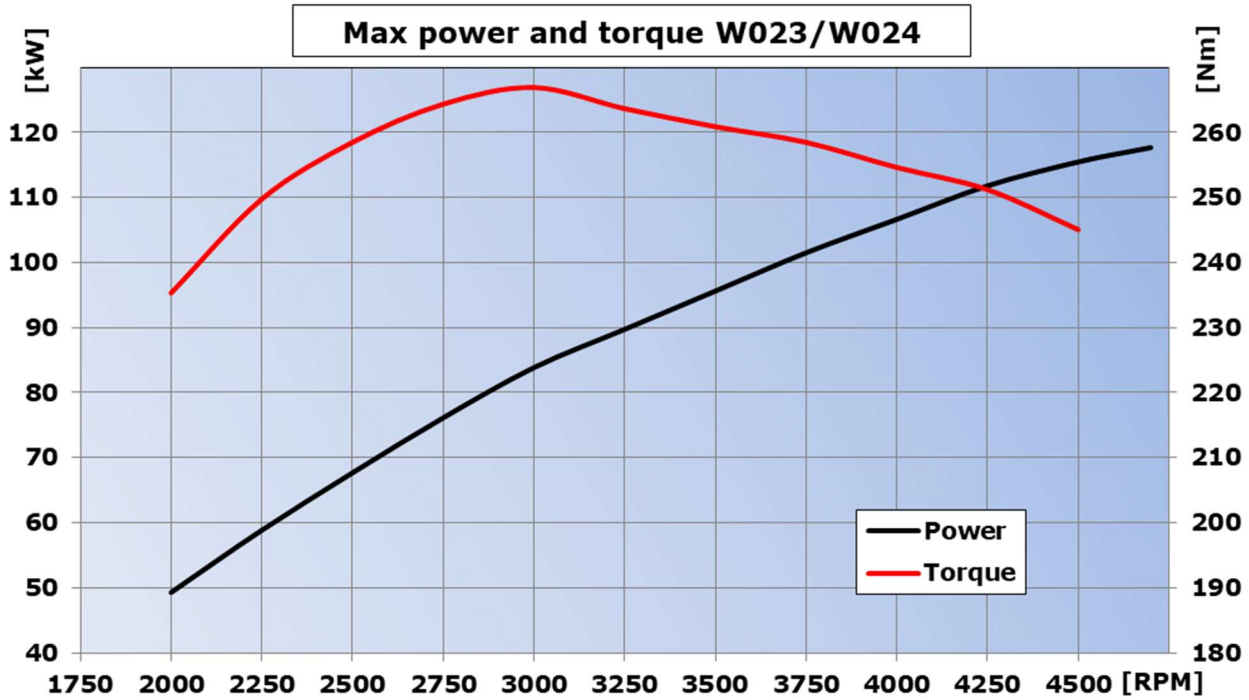

Power at costant MAP W017/W018
[kW]
100
90
80
70
60
50
40
30
20
10
1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 [RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-13-C*

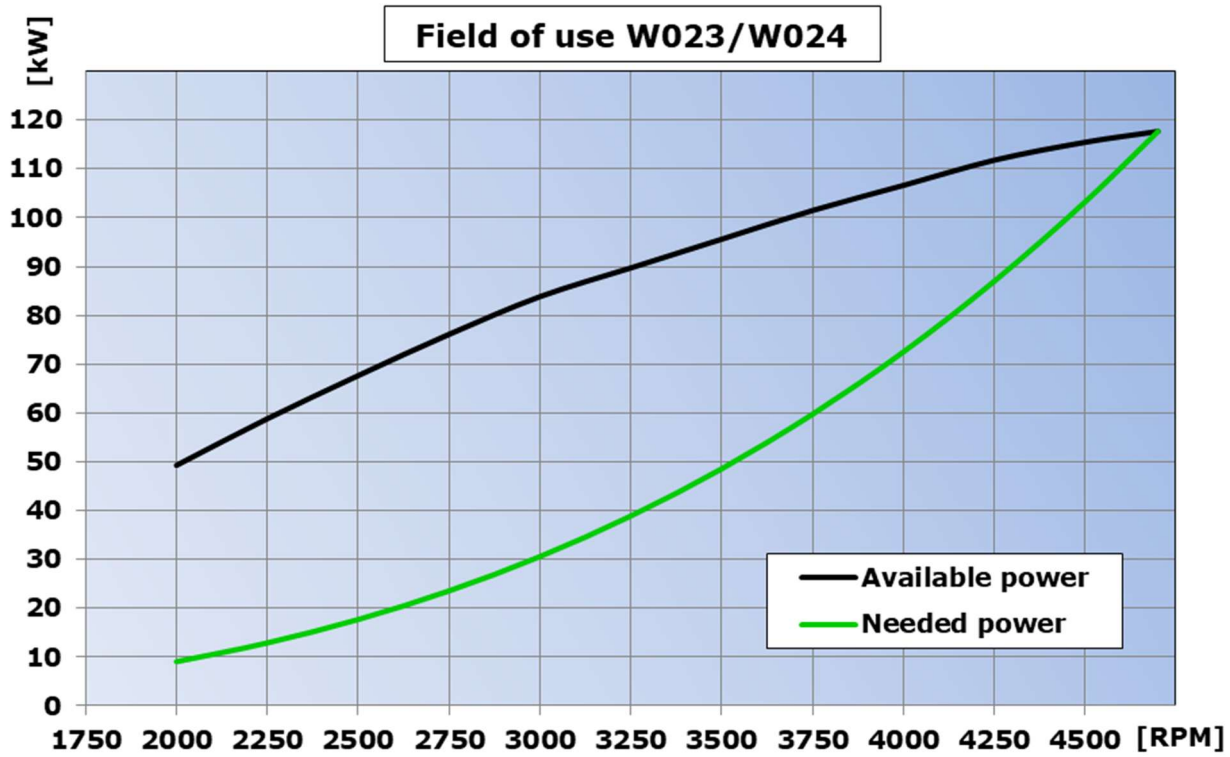

Power at constant rev's W017/W018
[kW]
100
90
80
70
60
50
40
30
20
10
22 23 24 25 26 27 28 29 [inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-14-C*

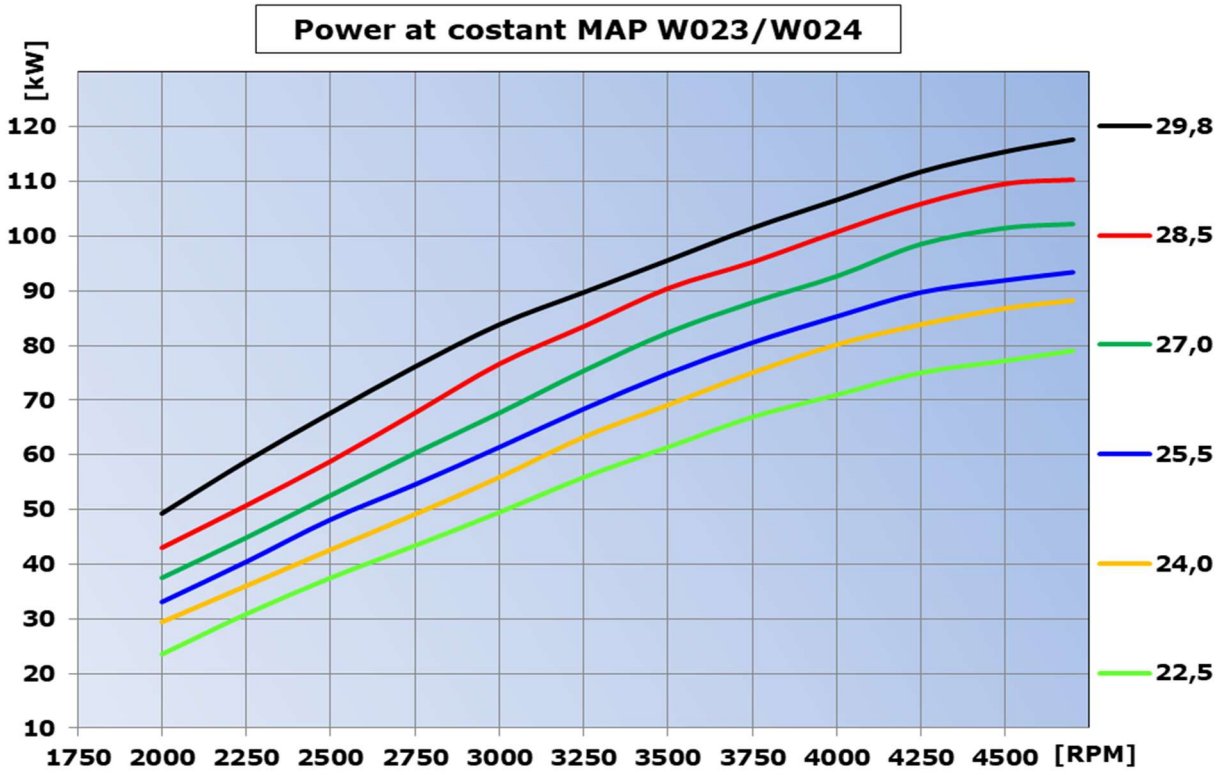
## 04-02-04 Spirit 160 Direct R/L



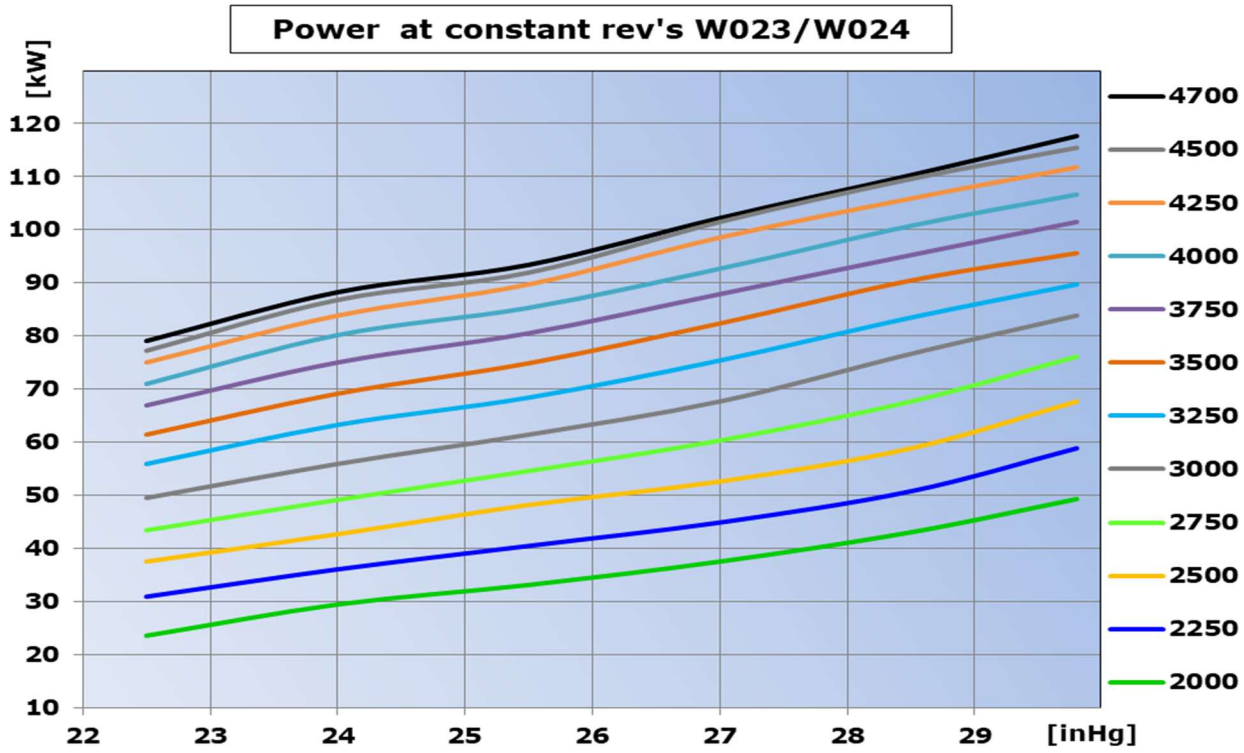

04-15-C




04-16-C

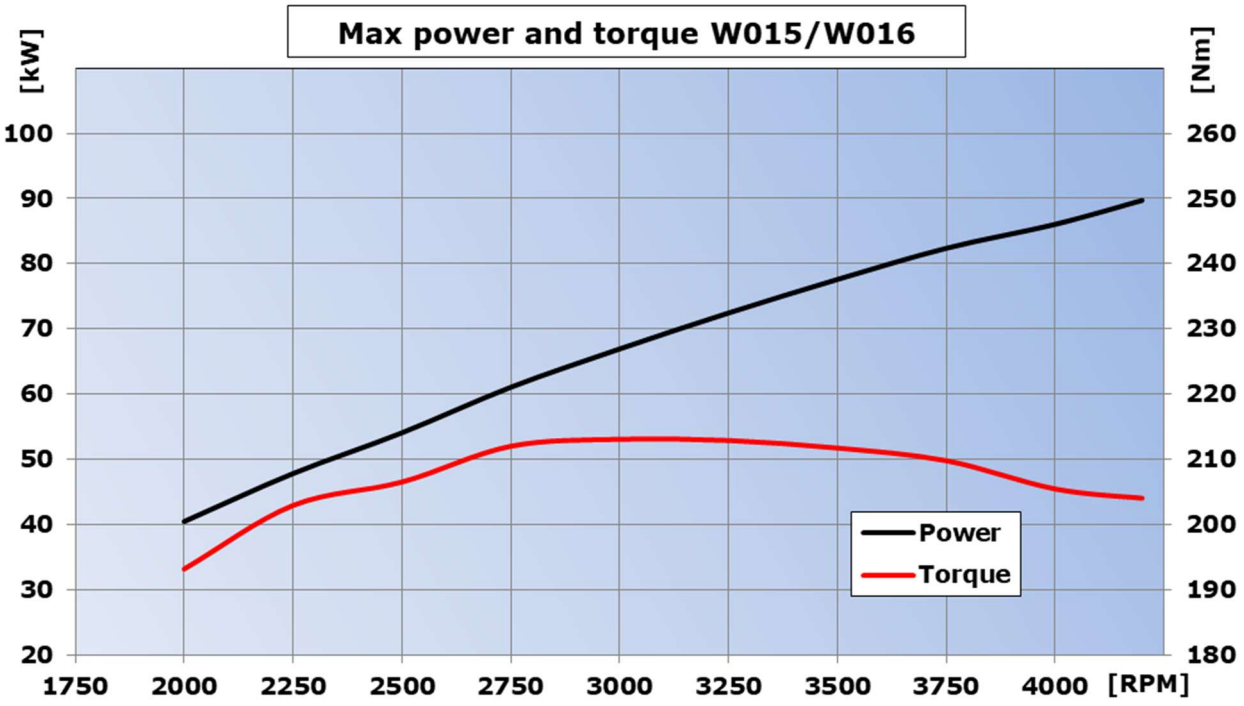

Power at costant MAP W023/W024
[kW]
120
110
100
90
80
70
60
50
40
30
20
10
1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 [RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-17-C*

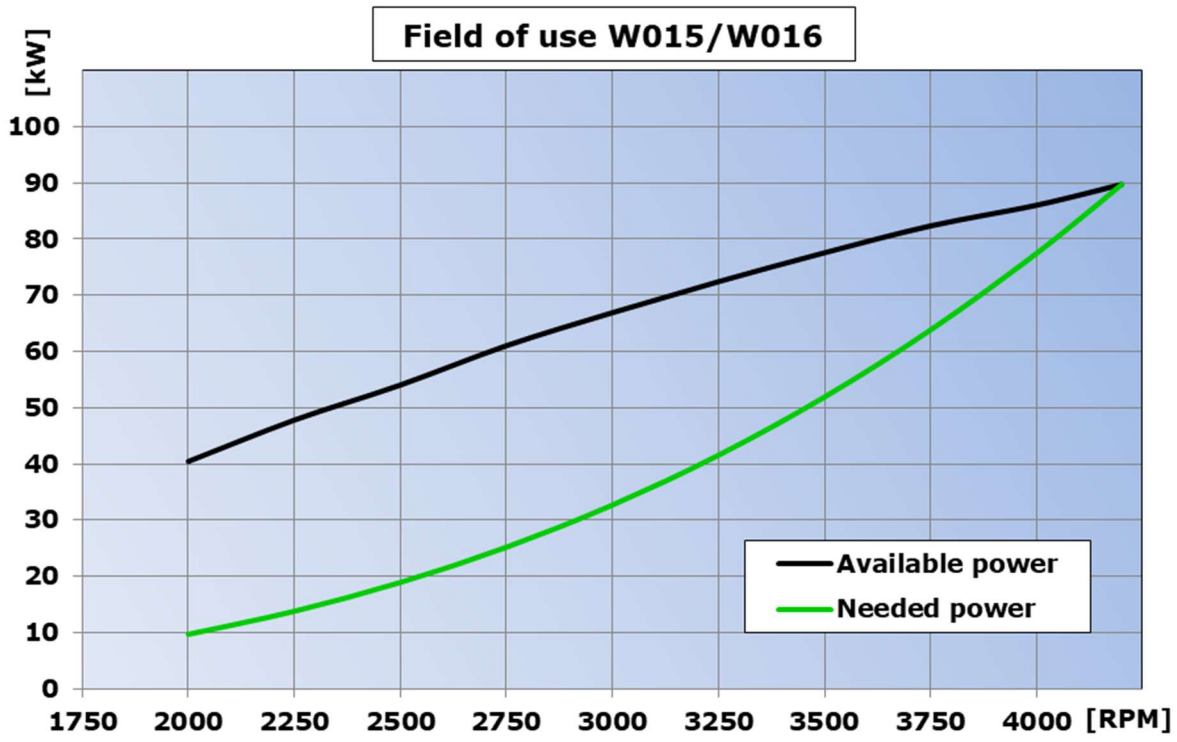

Power at constant rev's W023/W024
[kW]
120
110
100
90
80
70
60
50
40
30
20
10
22 23 24 25 26 27 28 29 [inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-18-C*

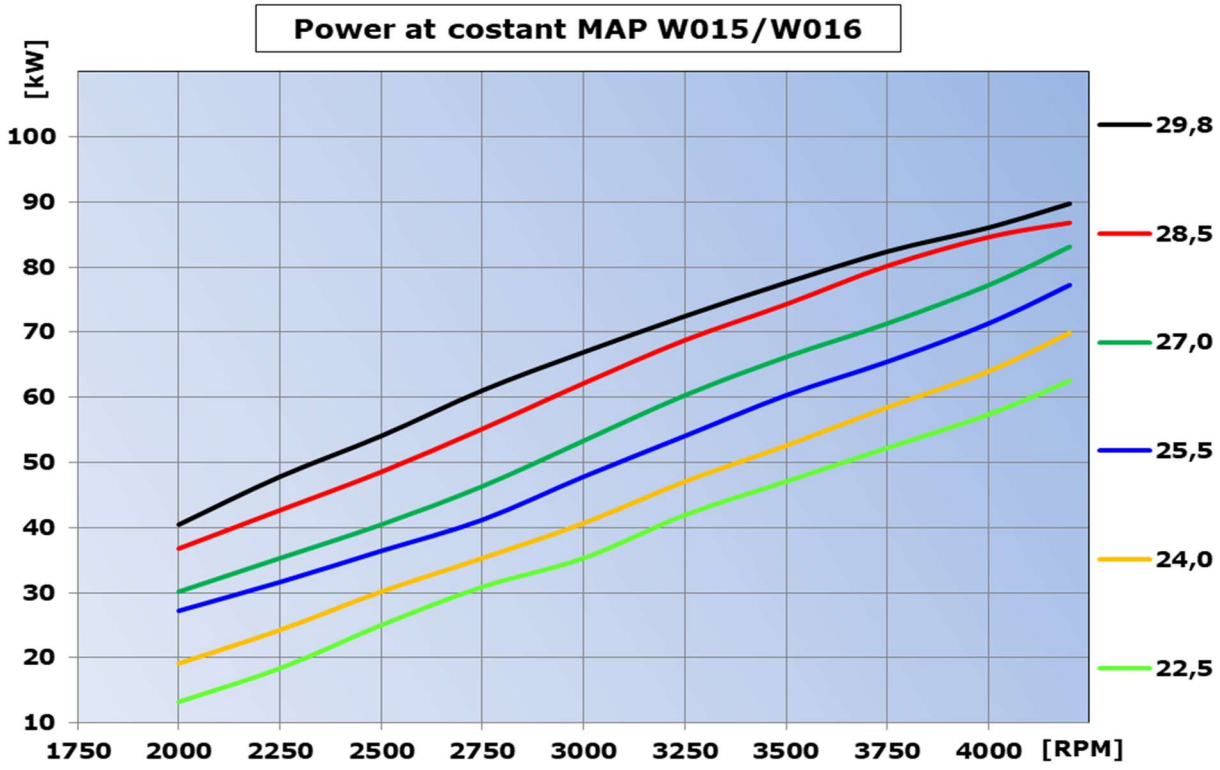
## 04-02-05 Spirit 122 PSRU R/L



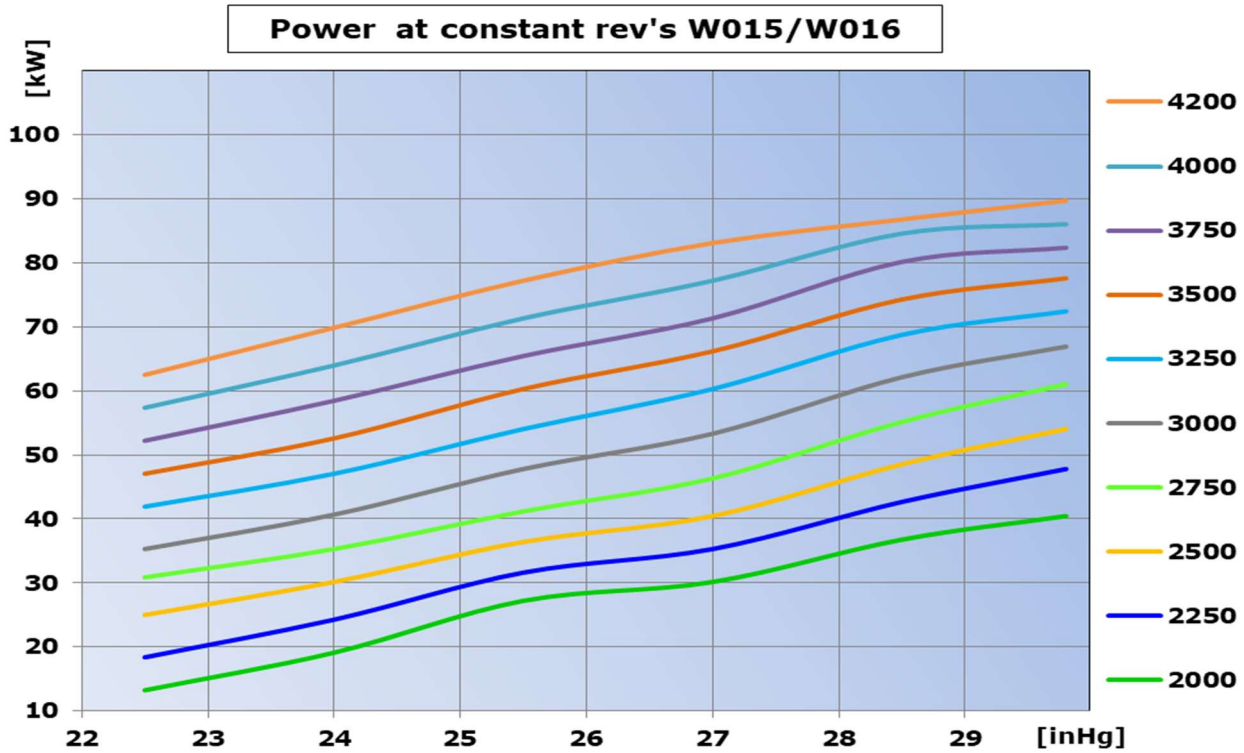

04-19-C




04-20-C

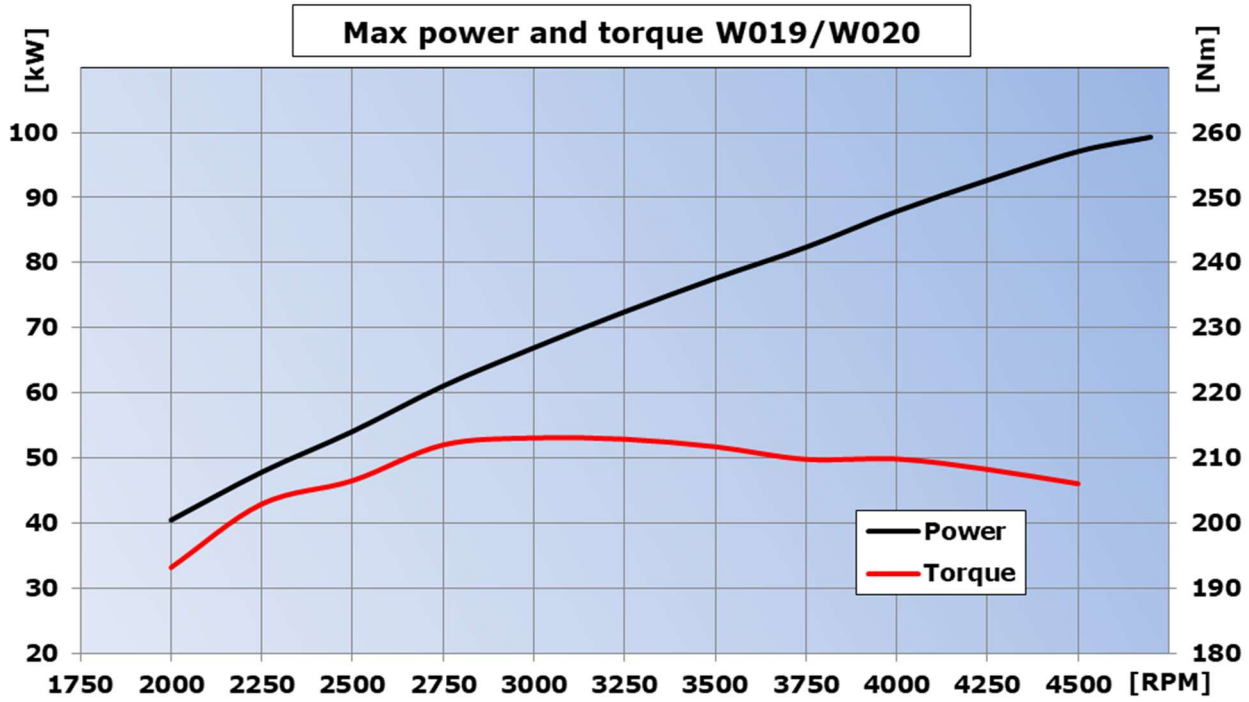

Power at costant MAP W015/W016
[kW]
100
90
80
70
60
50
40
30
20
10
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
[RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-21-C*

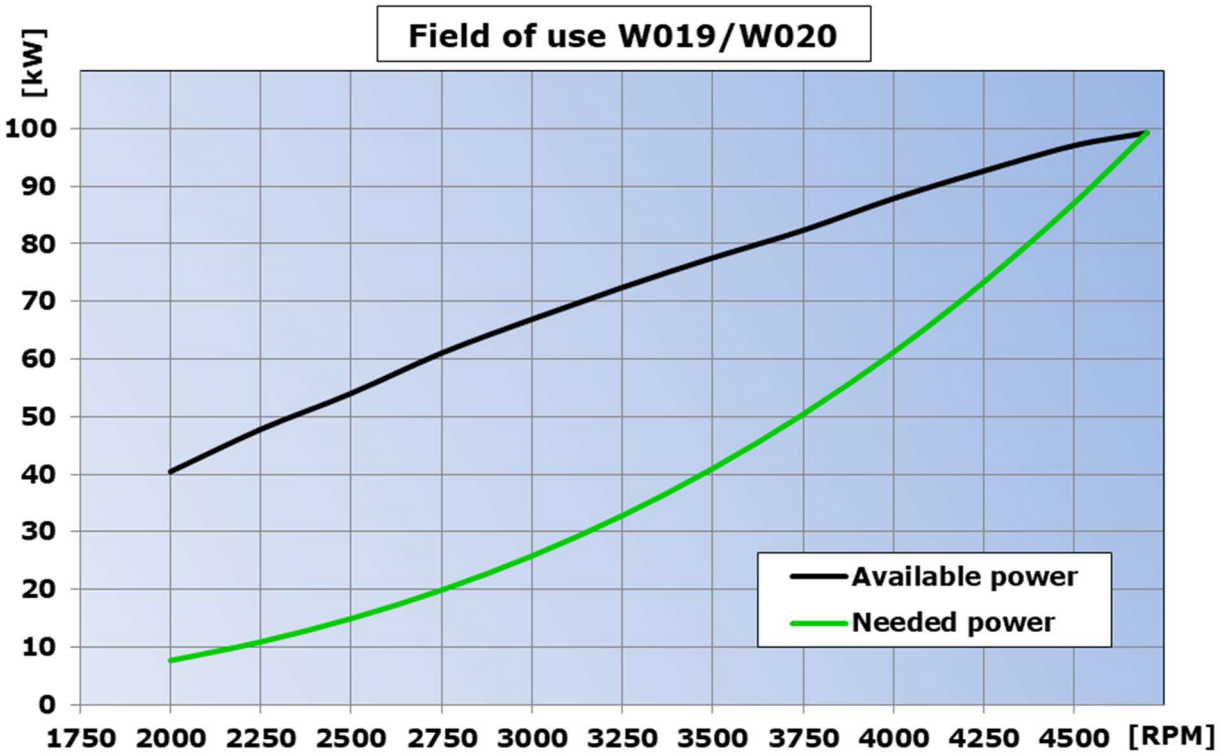

Power at constant rev's W015/W016
[kW]
100
90
80
70
60
50
40
30
20
10
22
23
24
25
26
27
28
29
[inHg]
4200
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-22-C*

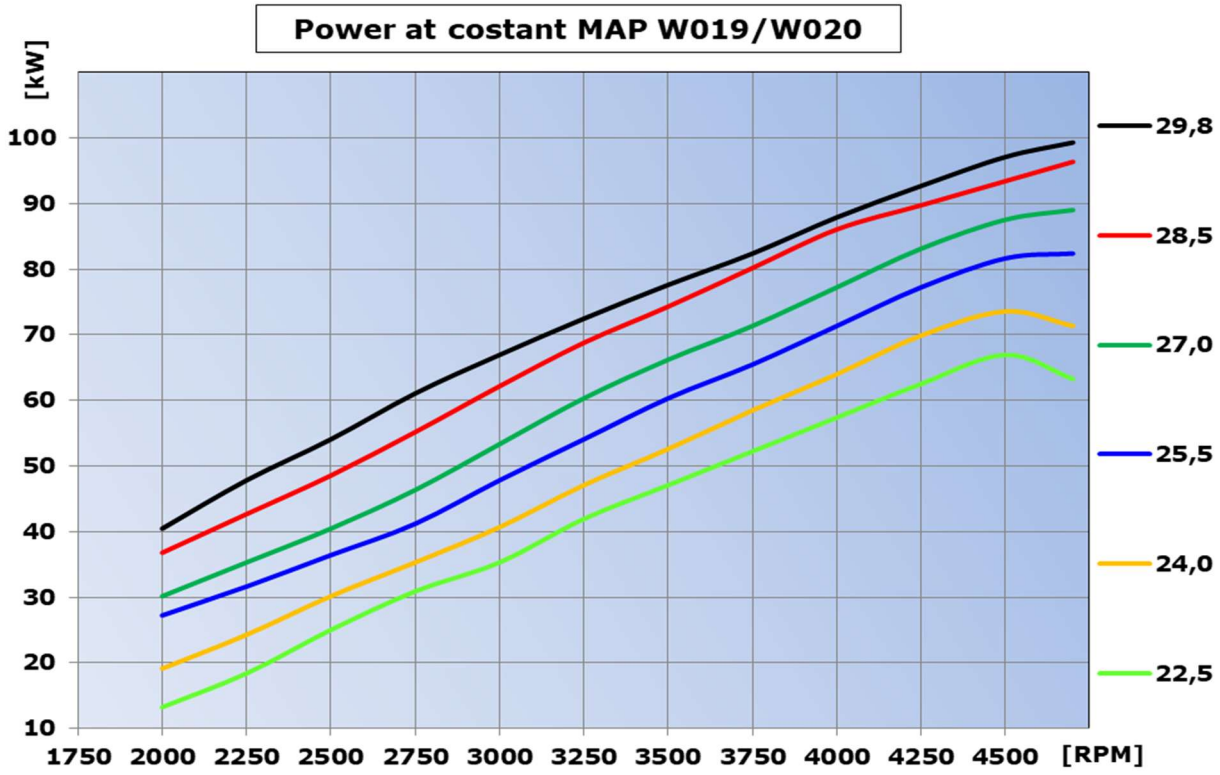
## 04-02-05 Spirit 135 PSRU R/L



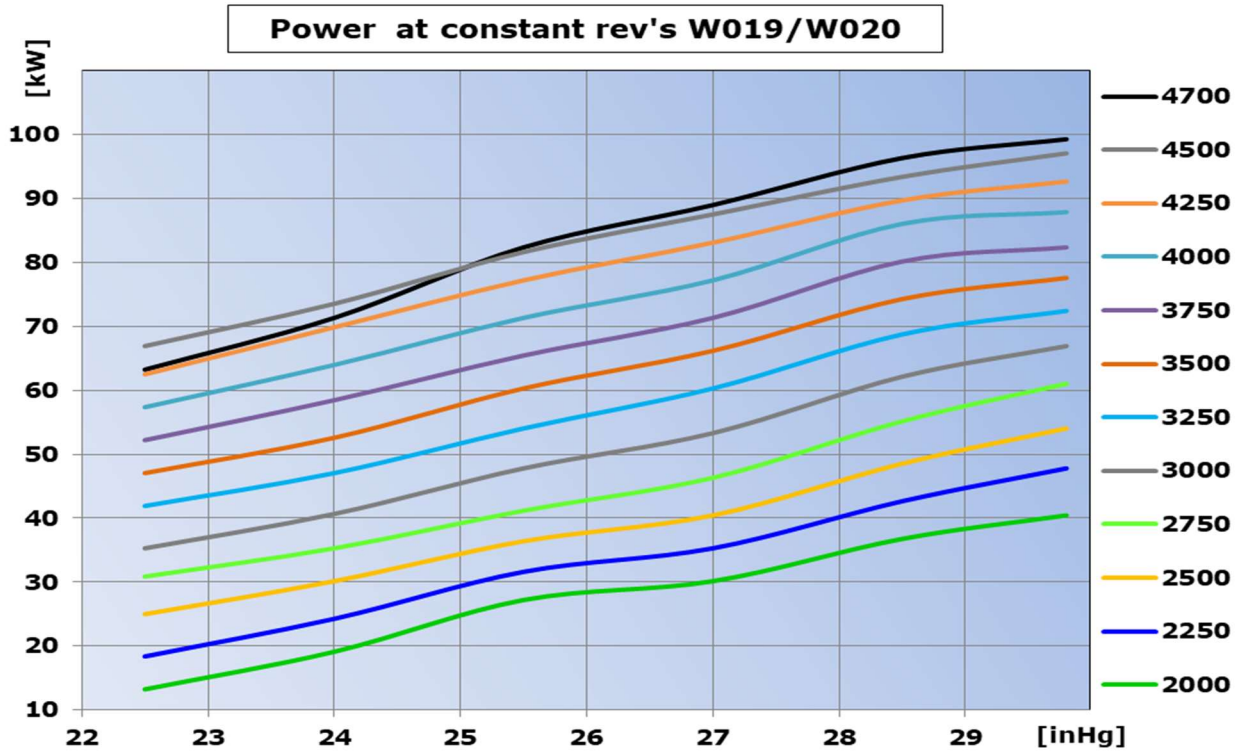

04-23-C




04-24-C

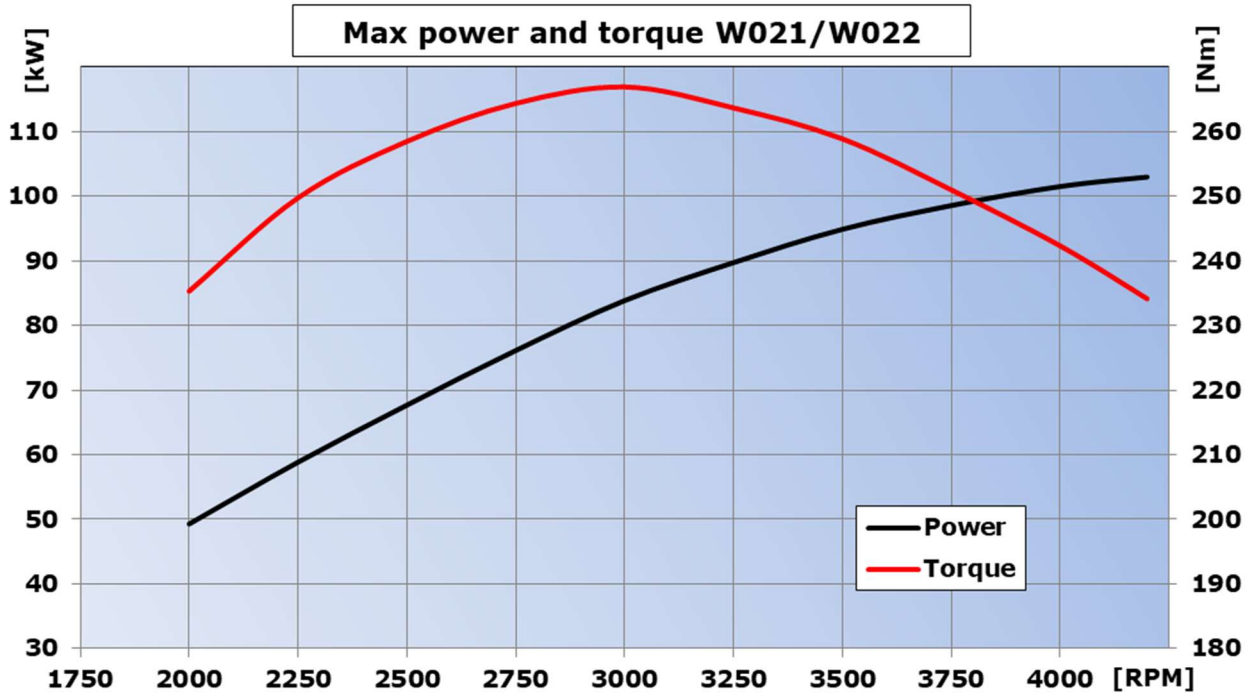

Power at costant MAP W019/W020
[kW]
100
90
80
70
60
50
40
30
20
10
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
4500
[RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-25-C*

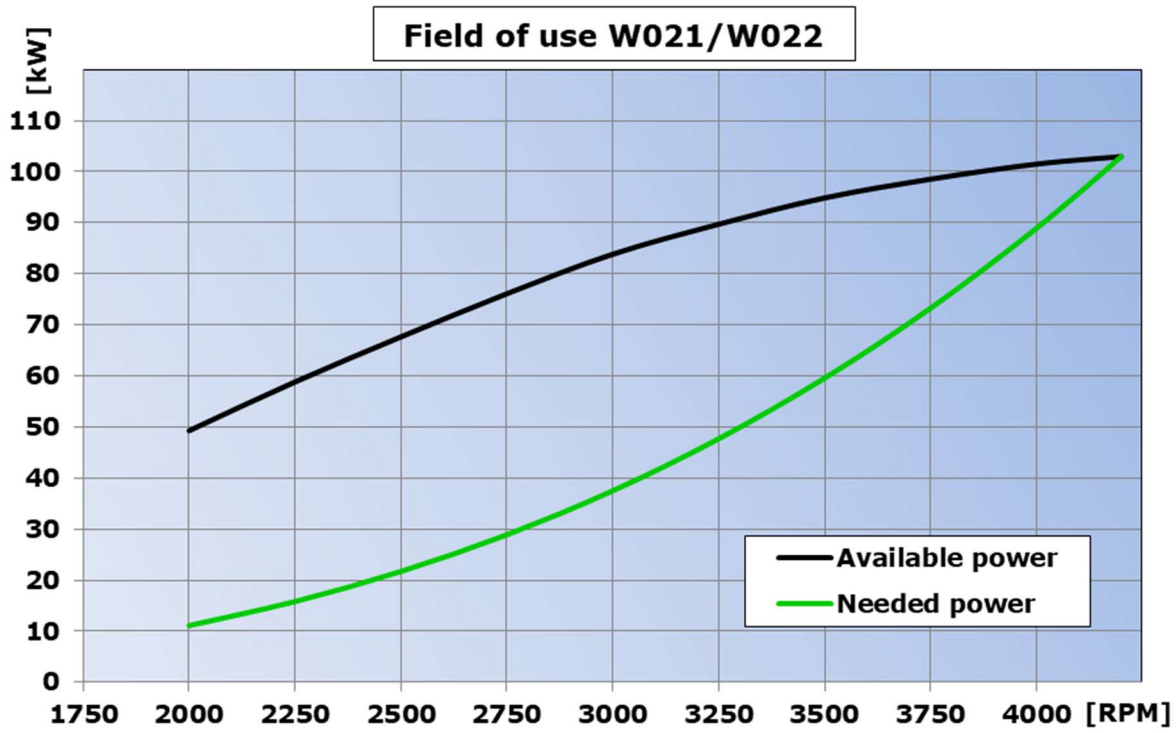

Power at constant rev's W019/W020
[kW]
100
90
80
70
60
50
40
30
20
10
22
23
24
25
26
27
28
29
[inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-26-C*

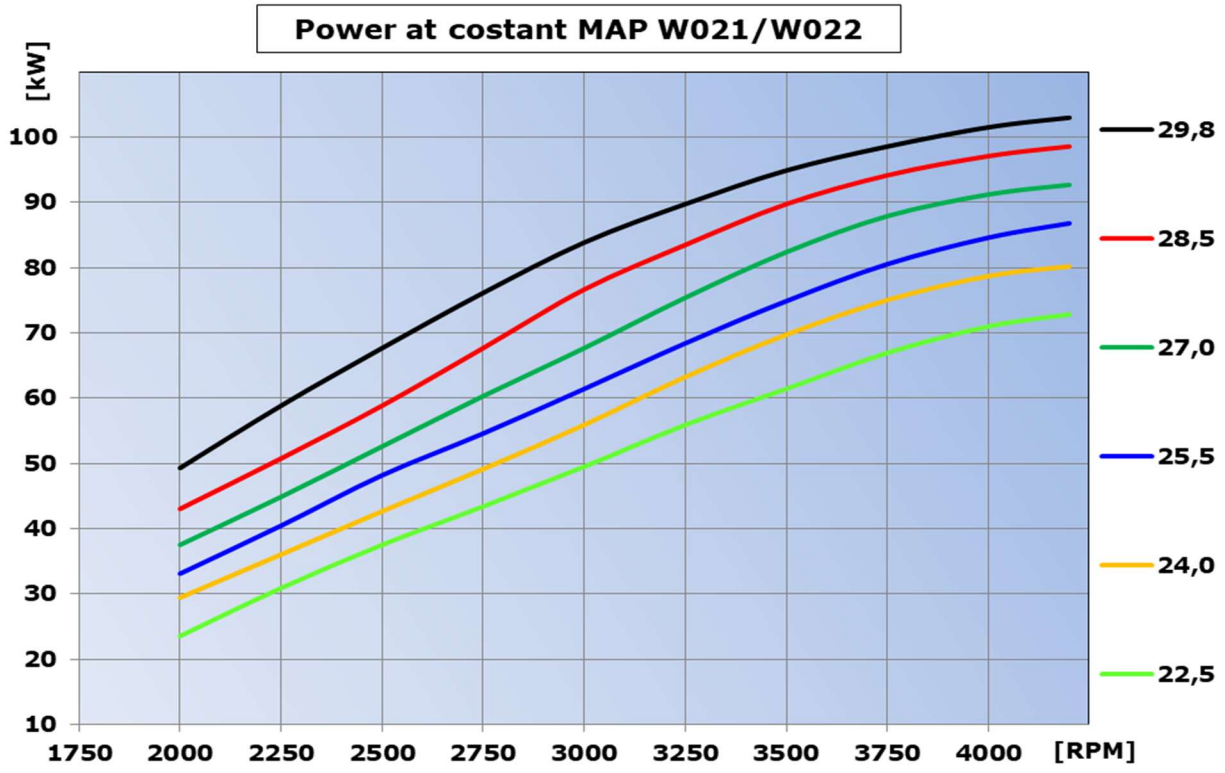
## 04-02-07 Spirit 140 PSRU R/L



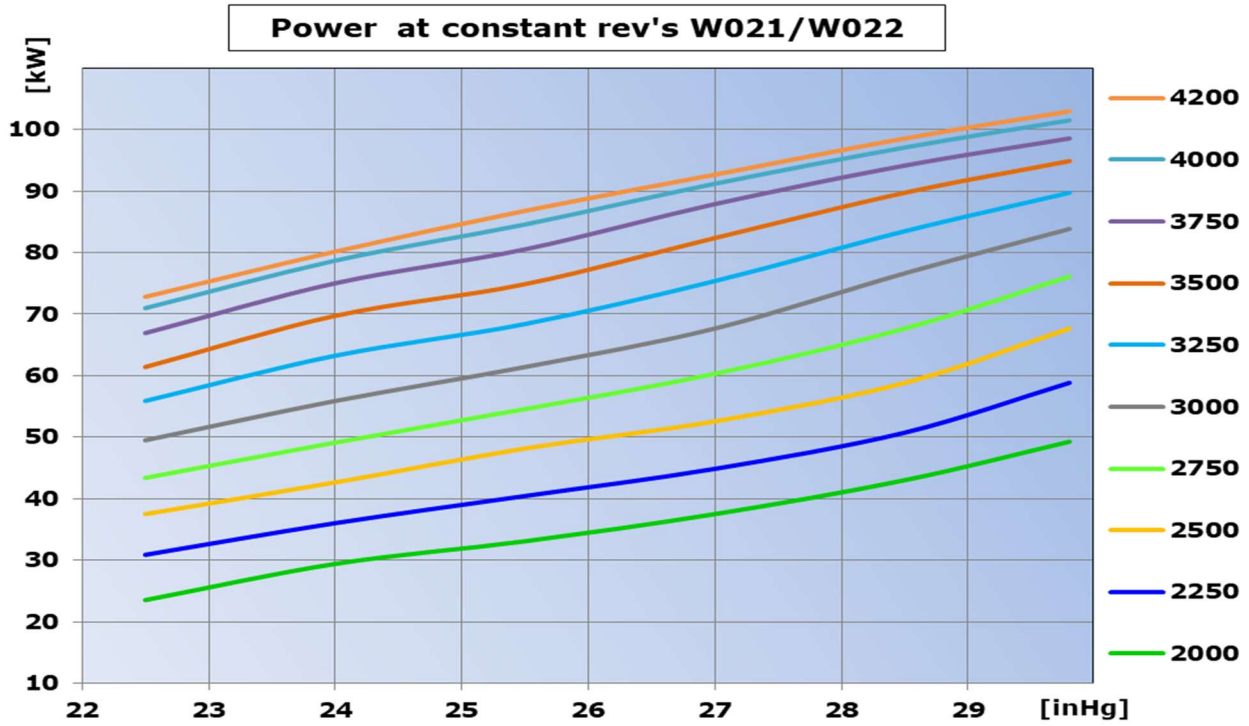

04-27-C




04-28-C

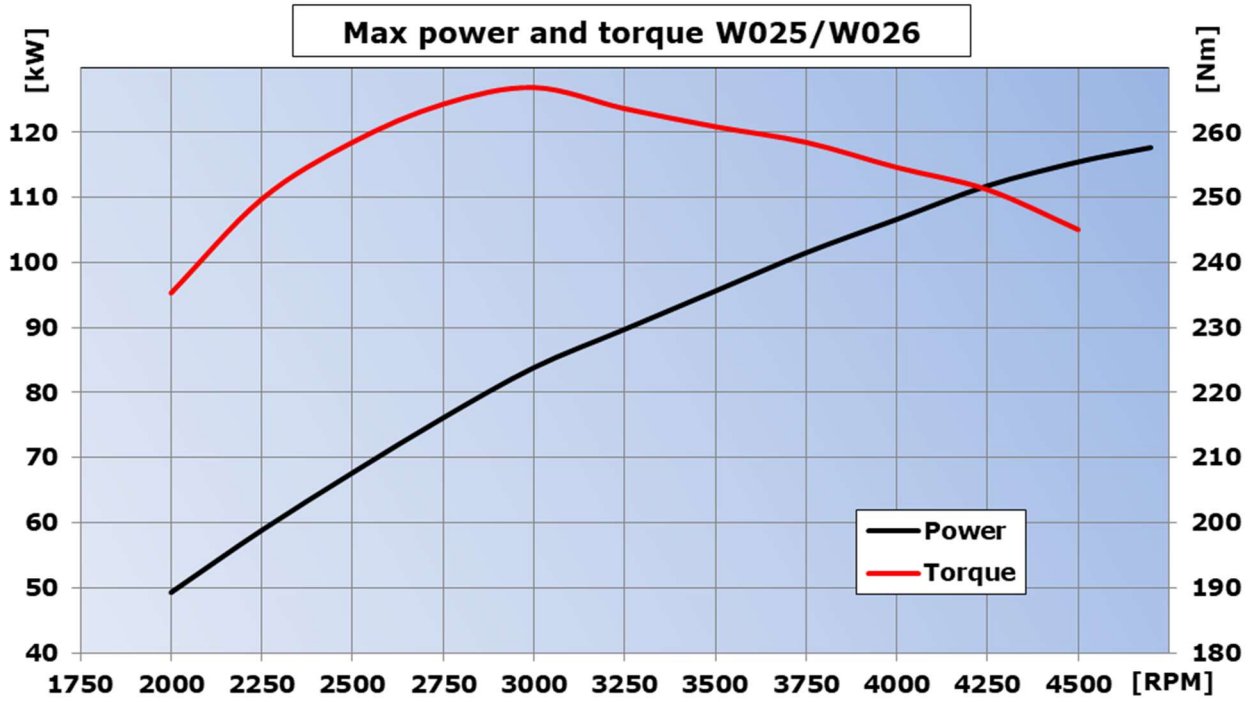

Power at costant MAP W021/W022
[kW]
100
90
80
70
60
50
40
30
20
10
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
[RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-29-C*

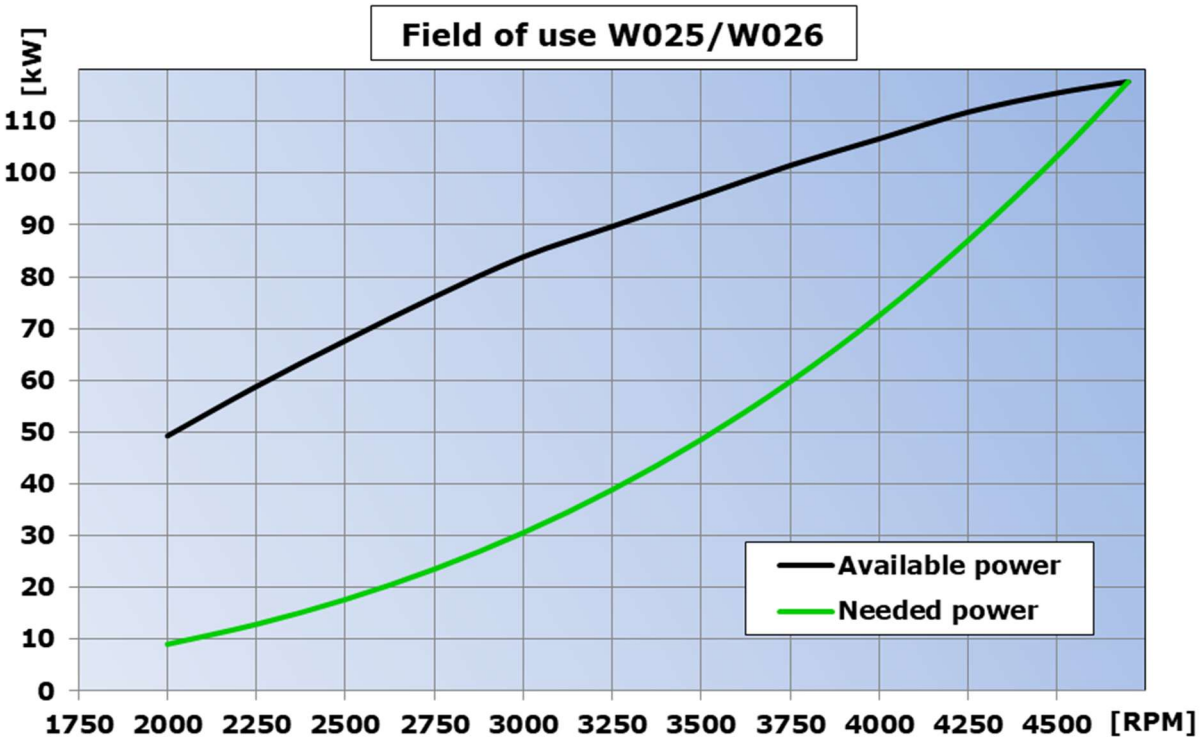

Power at constant rev's W021/W022
[kW]
100
90
80
70
60
50
40
30
20
10
22
23
24
25
26
27
28
29
[inHg]
4200
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-30-C*

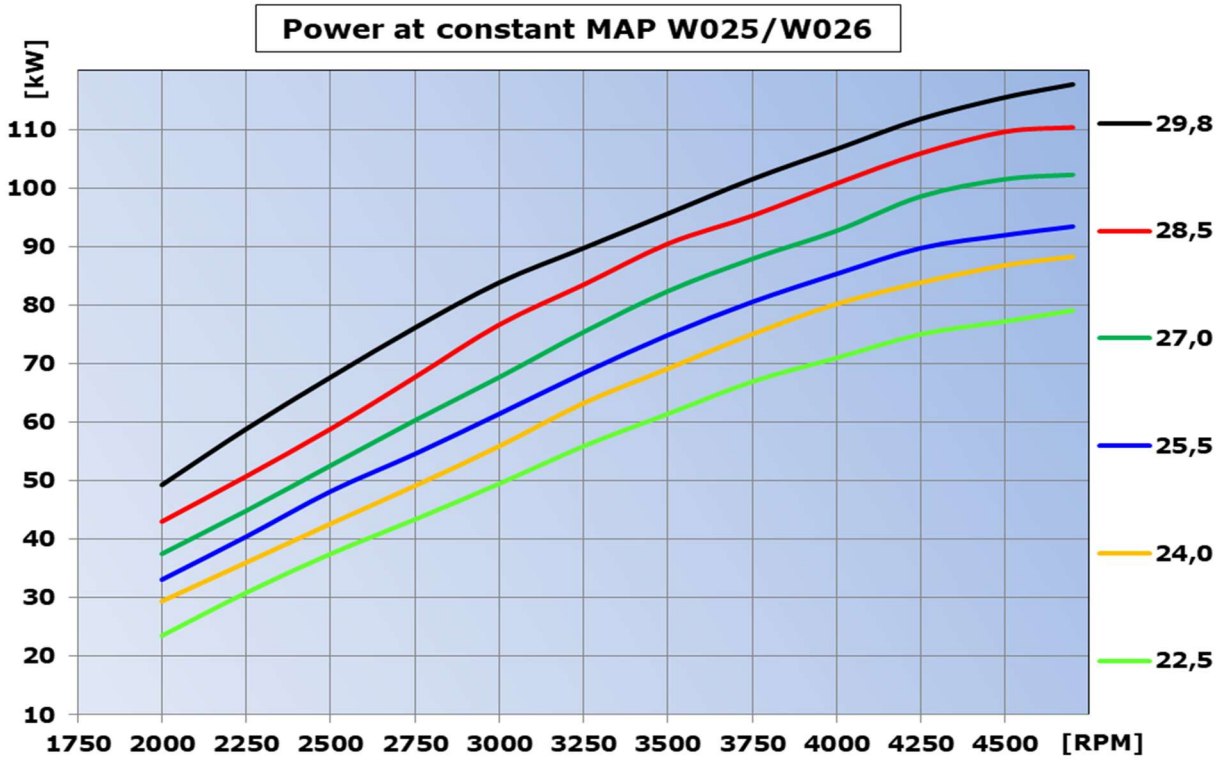
## 04-02-08 Spirit 160 PSRU R/L



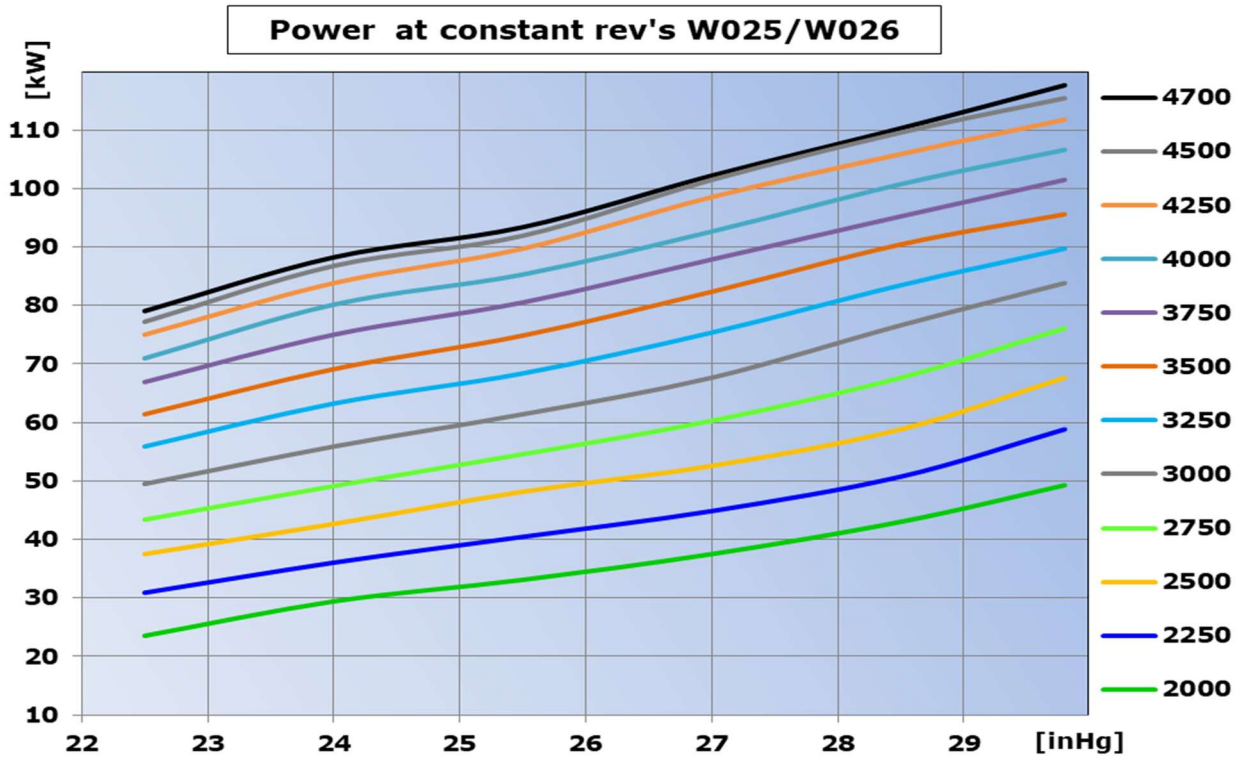

04-31-C




04-32-C


Power at constant MAP W025/W026
[kW]
110
100
90
80
70
60
50
40
30
20
10
1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 [RPM]
29,8
28,5
27,0
25,5
24,0
22,5

*04-33-C*

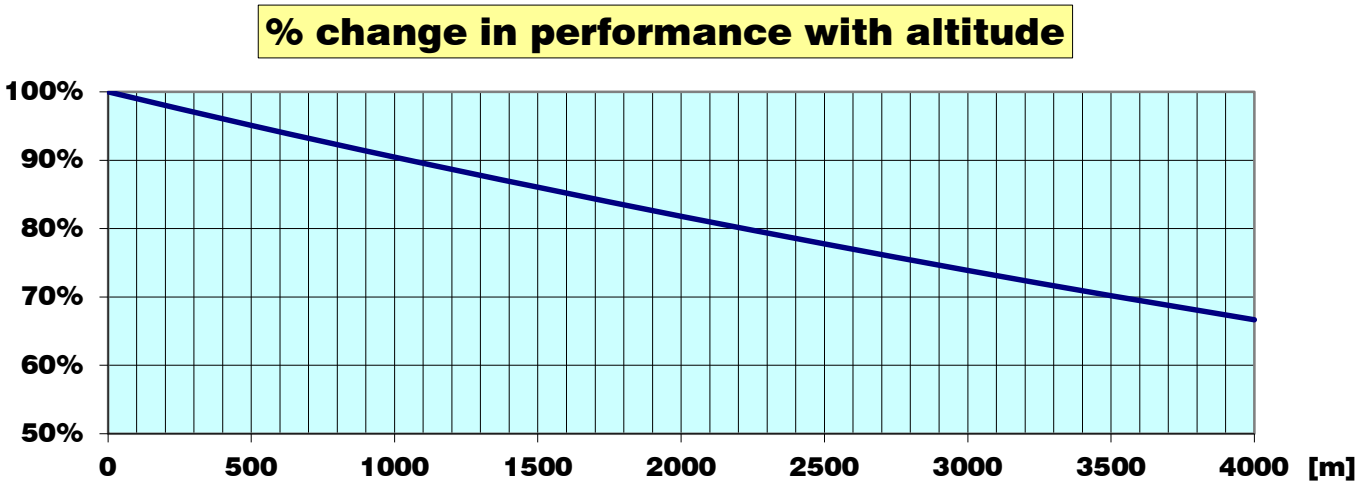

Power at constant rev's W025/W026
[kW]
110
100
90
80
70
60
50
40
30
20
10
22 23 24 25 26 27 28 29 [inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-34-C*

## *04-02-09 Performance variation*

Outside the ISA conditions, performance varies with changes in altitude, temperature and environmental humidity.

The variation in performance as the altitude varies can be calculated as a first approximation considering it equal to 1% every 100 meters of altitude. The following graph shows the performance variation trend in relation to the quota variation.



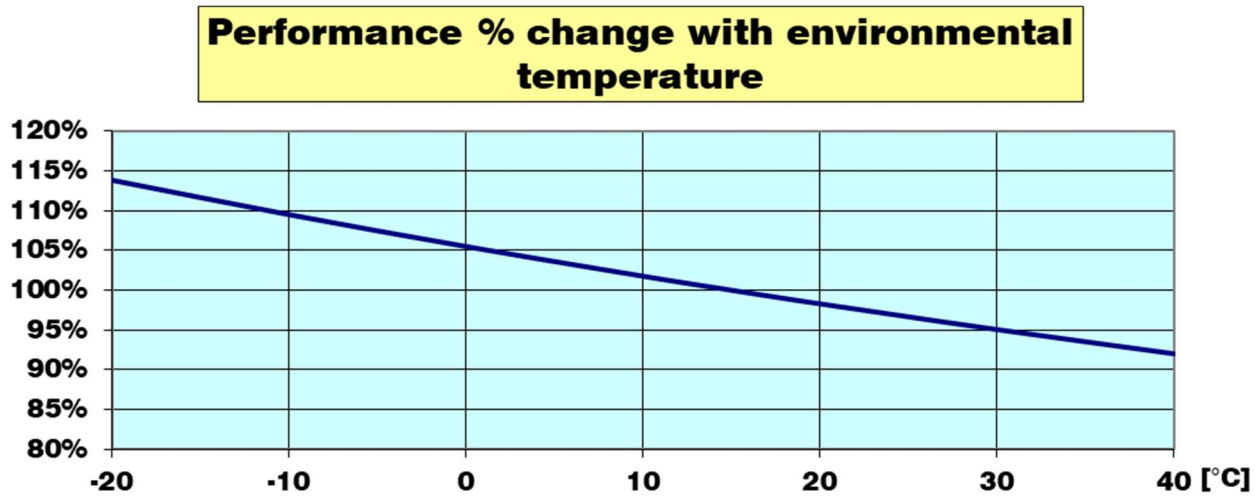

*04-35-C*

The engine power as the ambient temperature varies can be calculated according to the following formula, multiplying the power in a standard atmosphere (ISA) by 288 and dividing by the ambient temperature, expressed in degrees Kelvin.

$$Q=Q(ISA)*288/T(K)$$

The report is also recalled T(K)= T(°C)+273.

The following graph shows the performance variation trend as a function of atmospheric temperature.




*04-36-C*

The variation of performance as a function of atmospheric humidity is in turn a function of both the temperature variation and the atmospheric pressure variation: in this case, as a reference, at a temperature of 30°C and a pressure of 960mbar, one can consider a performance decay of about 0.5% for each 10% increase in relative humidity.

The injection system automatically varies the amount of the air/fuel mixture according to the variation in altitude and atmospheric temperature, in order to obtain the optimal carburetion in all environmental conditions.

## 04-03 Fuel consumption

Fuel consumption is linked to the power delivered and the fluid dynamic conditions of the engine.

All the data presented in the manuals relating to fuel consumption refer to operation with the injection map in Power mode: the activation of the Economy mode, if any, allows a saving of around 10% compared to the values shown.

The table below summarizes the power consumption for five typical flight conditions.

| Spirit Skyline versions | | | | |
|---|---|---|---|---|
| **Consumption [Kg/h] @rpm/MAP [inHg]** | 100 Direct R/L | 135 Direct R/L | 122 *PSRU R/L* | 140 PSRU R/L |
| *On takeoff* | 17,1 @3400/29,8 | 22,8 @4700/29,8 | 20,9 @4200/29,8 | 23,1 @4200/29,8 |
| *At the very least continue* | 17,1 @3400/29,8 | 20,5 @4520/27 | 18,3 @4060/27,6 | 20,1 @4060/27,3 |
| *At 75% power* | 12,3 @3090/26,4 | 17,4 @4270/25 | 14,9 @3810/25,3 | 15,9 @3810/25 |
| *At 65% power* | 10,8 @2940/25,5 | 14,7 @4070/23,6 | 13,2 @3640/24,4 | 14,2 @3640/23,5 |
| *At 55% power* | 9,6 @2780/24,8 | 12,6 @3850/22,6 | 11,5 @3440/23,5 | 12,8 @3440/22,2 |

*04-37-C*

| Spirit Redline versions | | | | |
|---|---|---|---|---|
| **Consumption [Kg/h] @rpm/MAP [inHg]** | 115 Direct R/L | 160 Direct R/L | 135 *PSRU R/L* | 160 PSRU R/L |
| *On takeoff* | 19,2 @3400/29,8 | 25,1 @4700/29,8 | 22,8 @4700/29,8 | 25,1 @4700/29,8 |
| *At the very least continue* | 19,2 @3400/29,8 | 22 @4520/27,5 | 19,6 @4450/26,5 | 21,4 @4450/27,2 |
| *At 75% power* | 15,2 @3090/27,4 | 18,5 @4270/25,3 | 17,4 @4270/25 | 18,5 @4270/25,3 |
| *At 65% power* | 13,3 @2940/27 | 16,5 @4070/23,6 | 14,7 @4070/23,6 | 16,5 @4070/23,6 |
| *At 55% power* | 12,3 @2780/25,8 | 14,6 @3850/22,3 | 12,6 @3850/22,6 | 14,6 @3850/22,3 |

*04-38-C*

The consumption shown in the table refers to operation with a fixed-pitch propeller, in which the percentage of power supplied is uniquely linked to the engine rpm. If a variable-pitch propeller is used in flight, the consumption, with the same power output, can be obtained from the graphs on the following pages. As an indication, consider that generally lower consumption is obtained for the same power output, favoring flight conditions with high throttle opening and lower number of revolutions.

The following paragraphs show the summary graphs of consumption for each engine model.

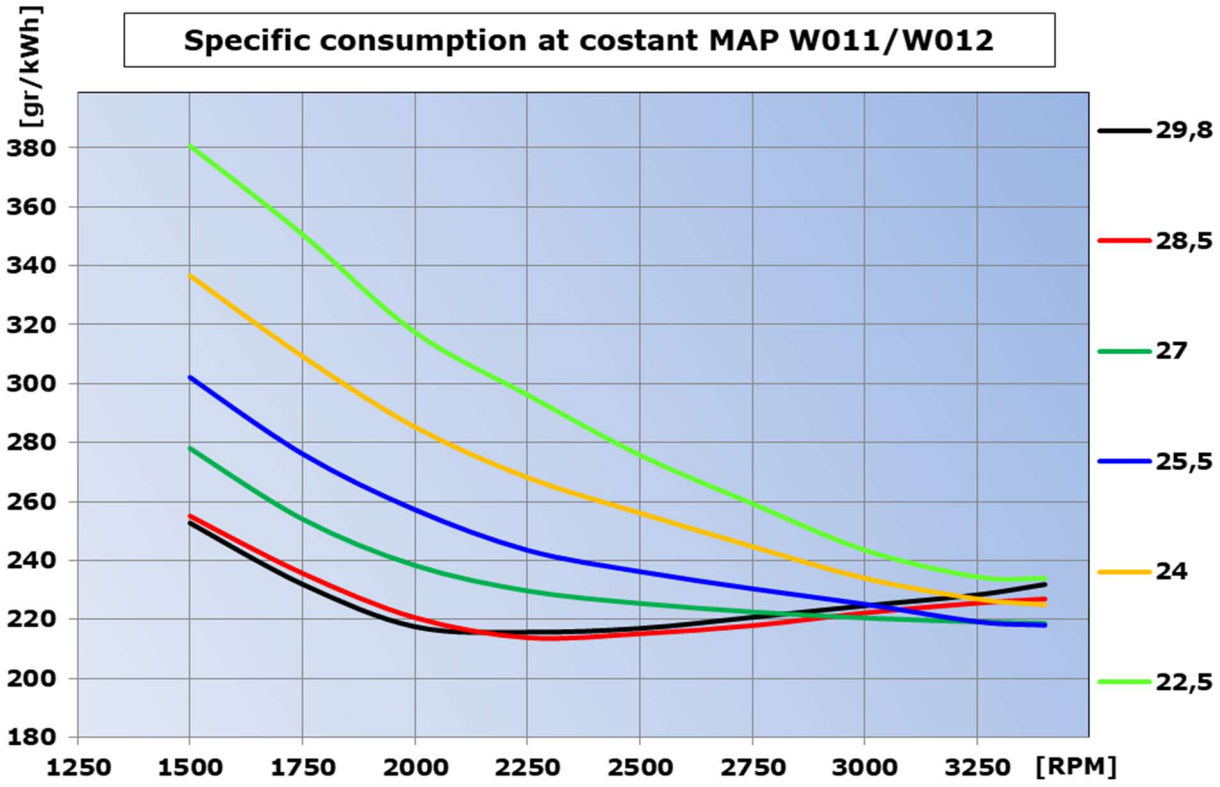
- Specific consumption/MAP at constant revolutions: each curve refers to a value of depression in the intake manifold (MAP), expressed in inches of mercury (inHg), and represents the grams of fuel needed in one hour for each horsepower delivered power.

- Hourly consumption for engines with fixed pitch propeller: the graph shows the hourly consumption expressed in kilograms and the corresponding vacuum in the intake manifold (MAP), expressed in inches of mercury, in the hypothesis of using a fixed pitch propeller capable to reach and not exceed the maximum power revs in flight.
- Hourly consumption/rpm at constant MAP: each curve refers to a vacuum value in the intake manifold (MAP), expressed in inches of mercury (inHg) and shows the hourly consumption expressed in kilograms, obtainable as a function of the engine speed.
- Hourly consumption/MAP at constant rpm: each curve refers to an engine rotation speed and shows the hourly consumption expressed in kilograms, obtainable as a function of the vacuum in the intake manifold (MAP).

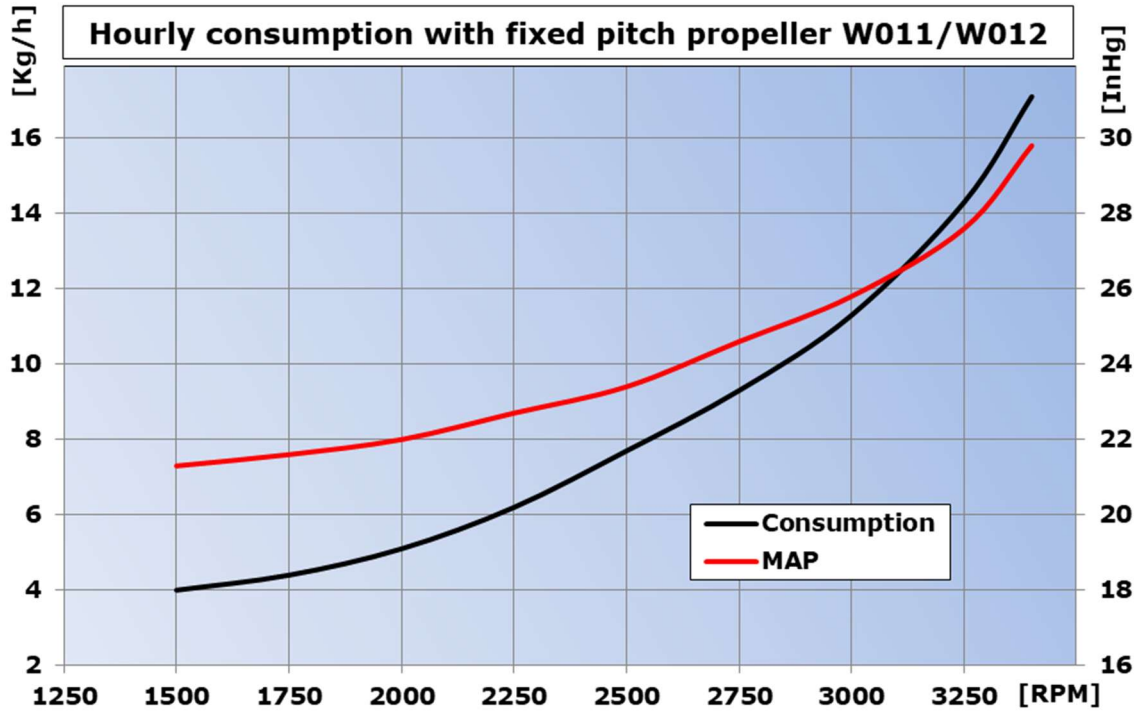
The maximum MAP value shown in the graphs is the maximum obtainable at full throttle opening with a barometric pressure of 1013 mbar.

Deviations from the curves shown are possible in the amount of 5%, as a result of dimensional and assembly tolerances.

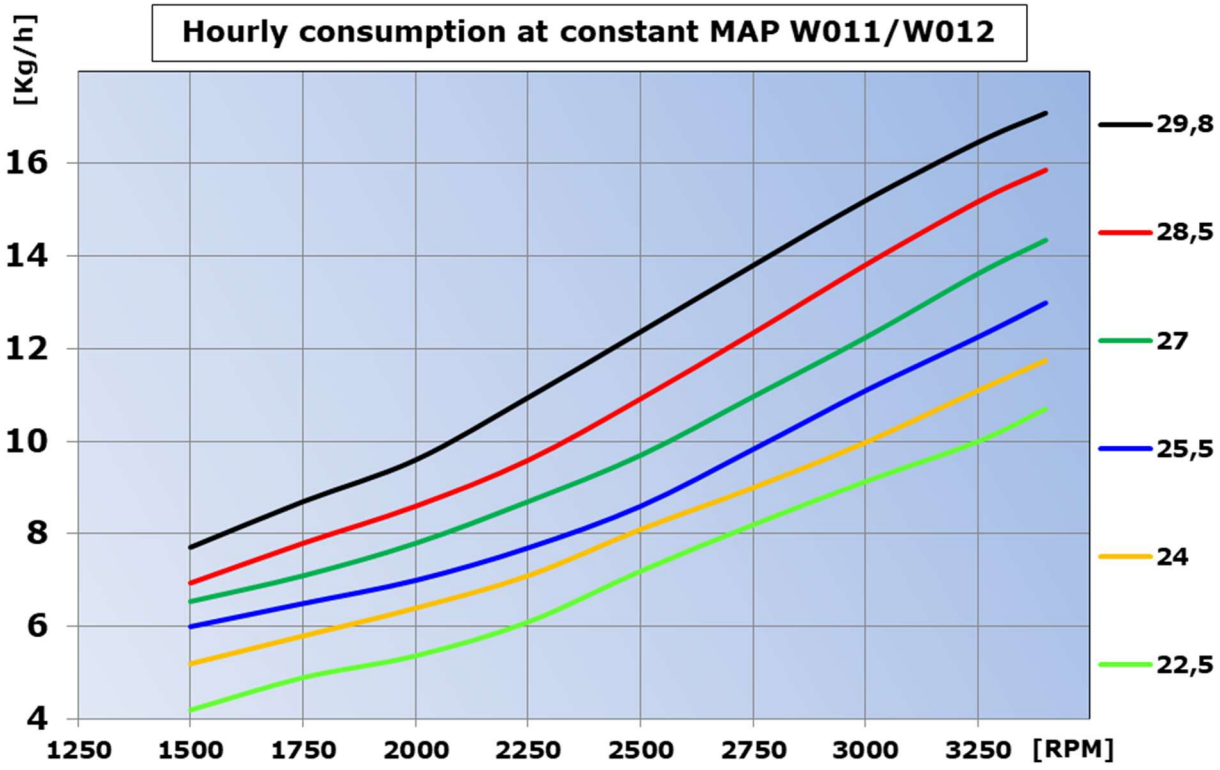
*04-03-01 Spirit 100 Direct R/L*



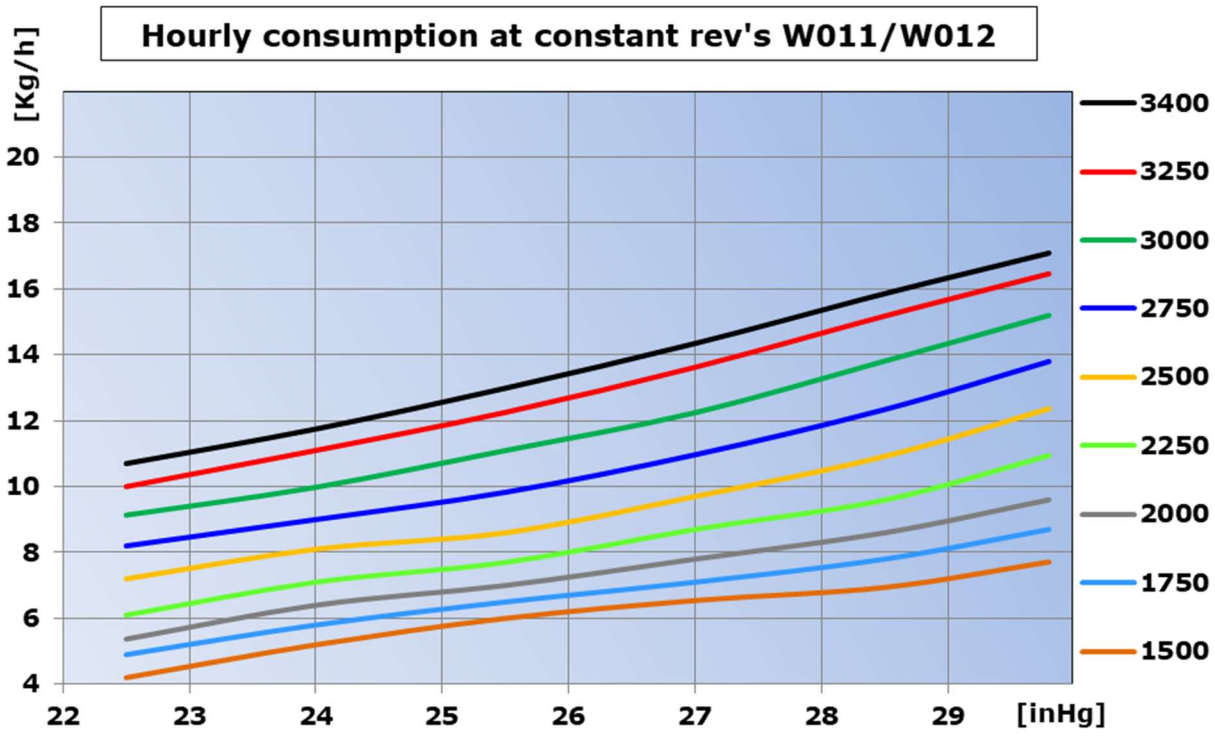

*04-39-C*




*04-40-C*

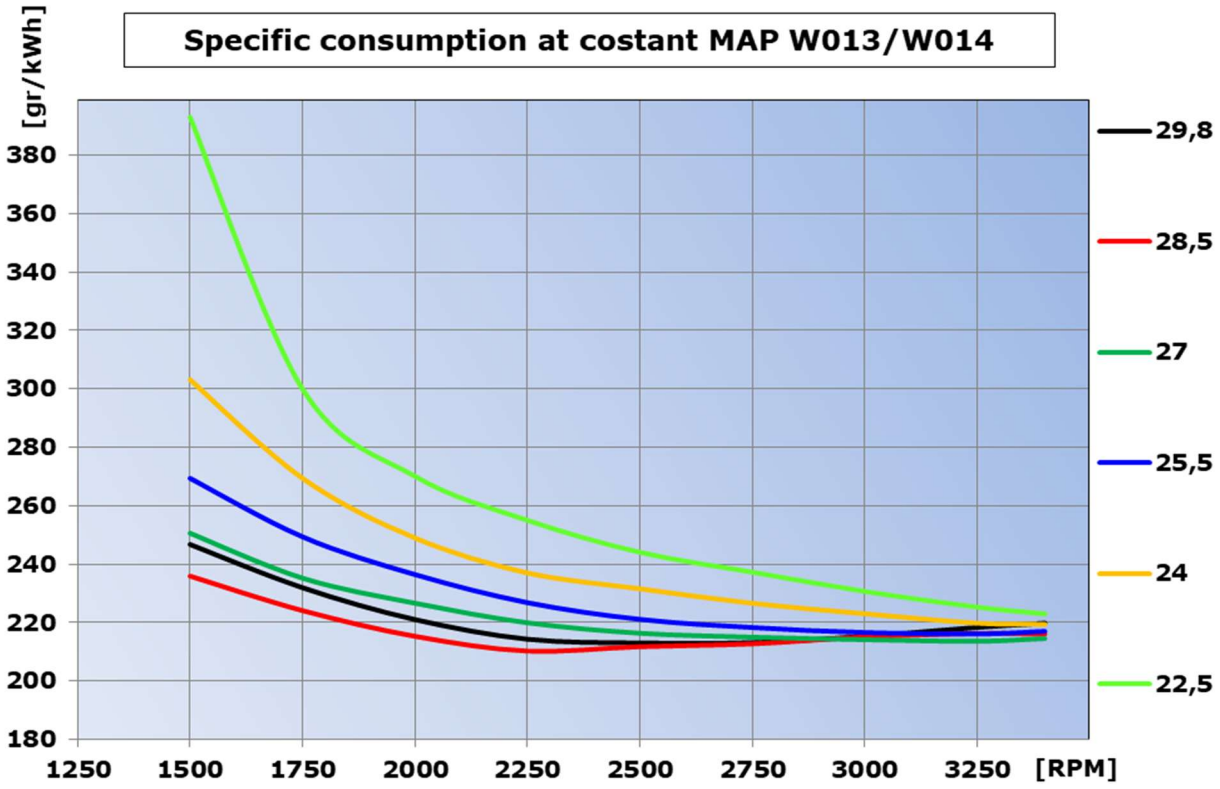

Hourly consumption at constant MAP W011/W012
[Kg/h]
16
14
12
10
8
6
4
1250
1500
1750
2000
2250
2500
2750
3000
3250
[RPM]
29,8
28,5
27
25,5
24
22,5

*04-41-C*

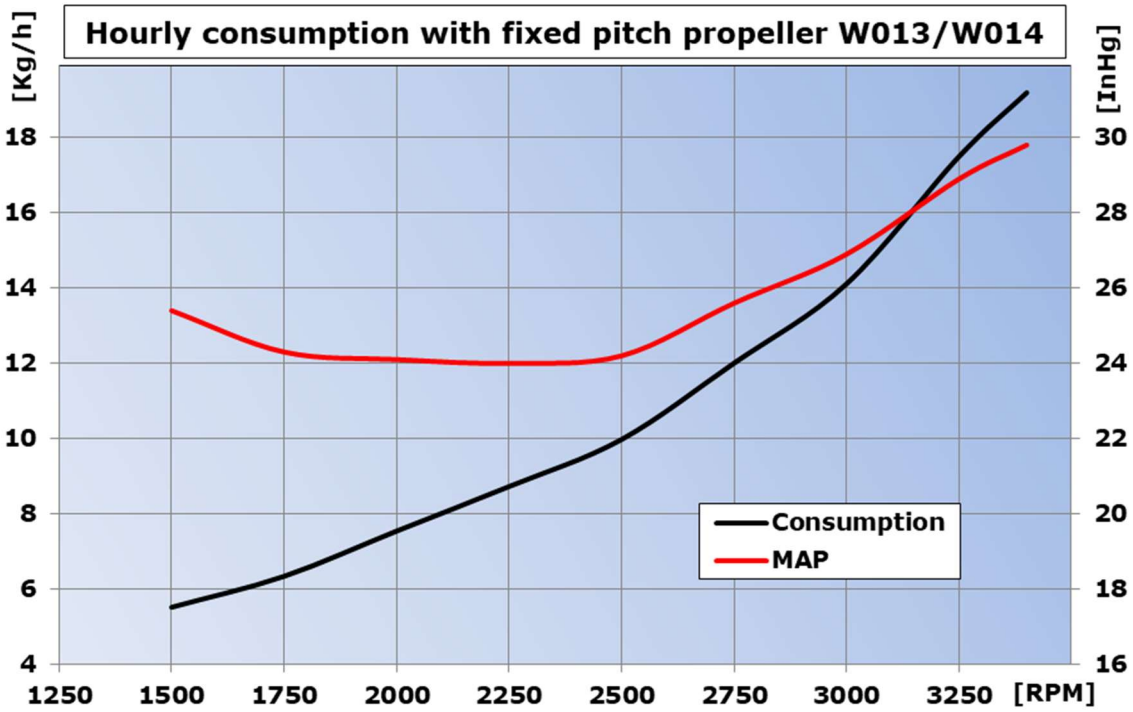

Hourly consumption at constant rev's W011/W012
[Kg/h]
20
18
16
14
12
10
8
6
4
22
23
24
25
26
27
28
29
[inHg]
3400
3250
3000
2750
2500
2250
2000
1750
1500

*04-42-C*

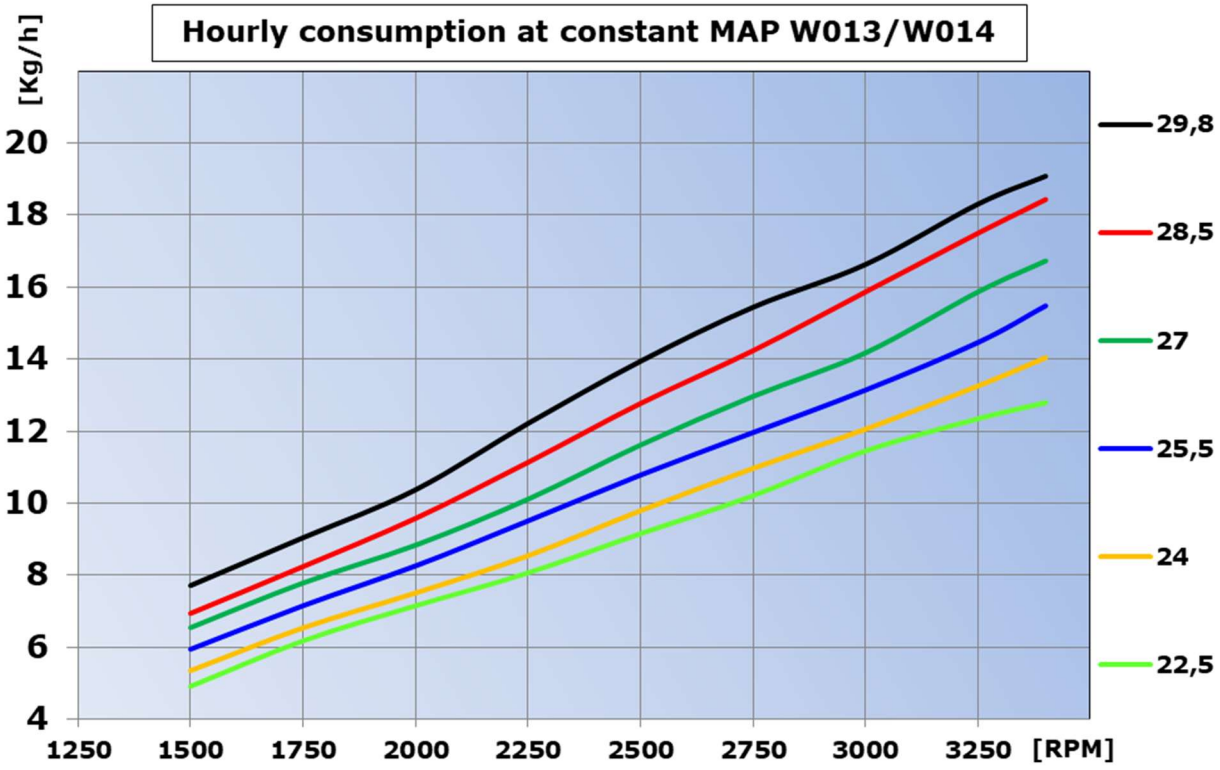
*04-03-02 Spirit 115 Direct R/L*



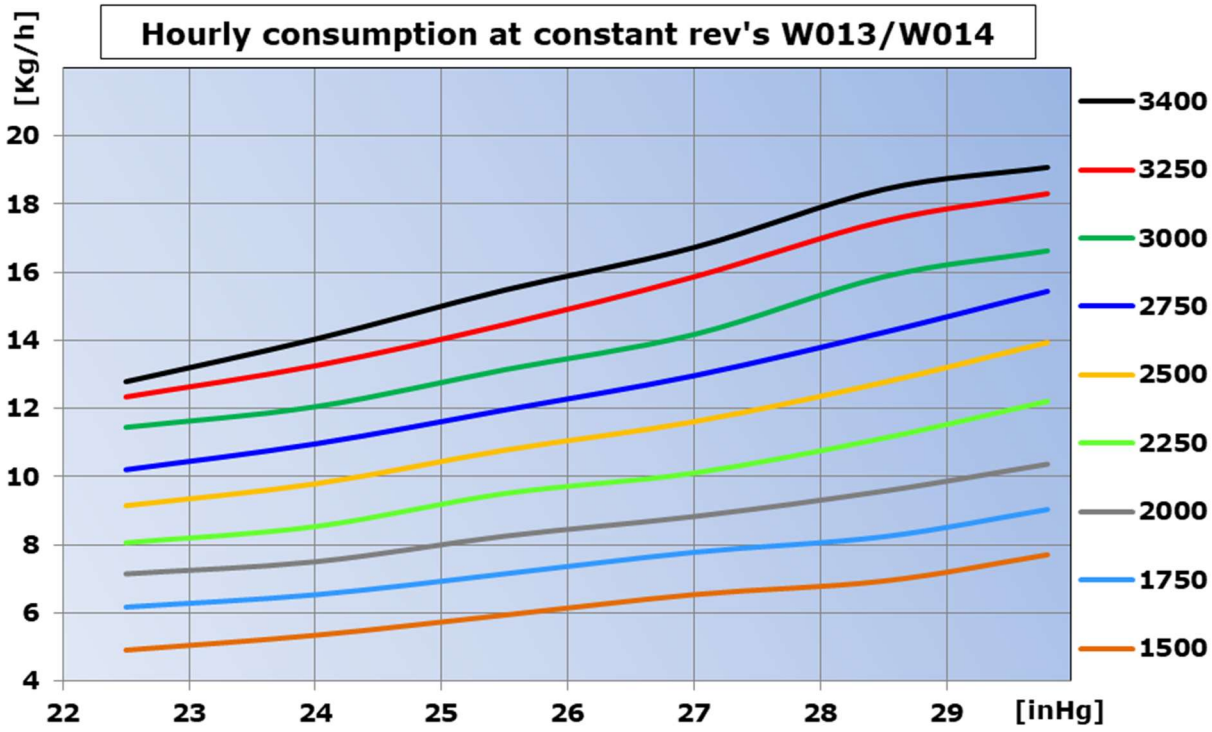

*04-43-C*




*04-44-C*

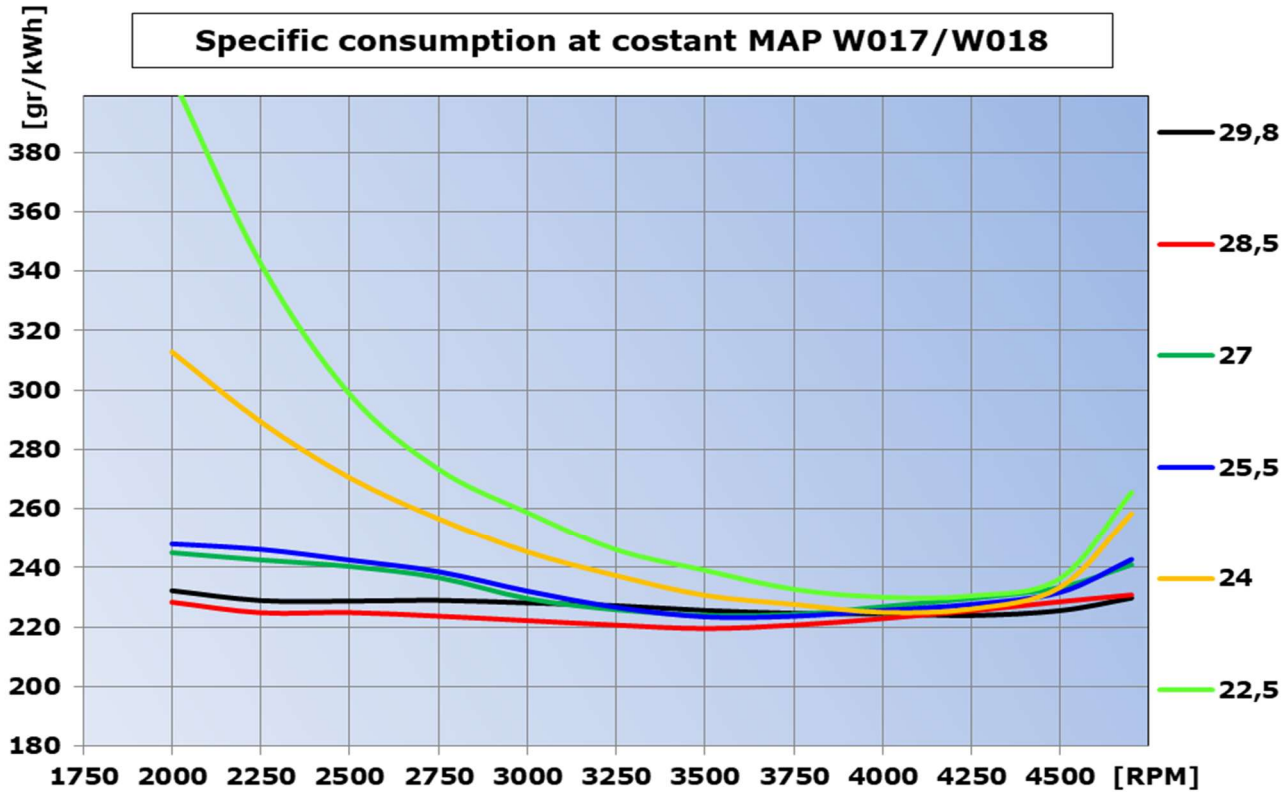

Hourly consumption at constant MAP W013/W014
[Kg/h]
20
18
16
14
12
10
8
6
4
1250
1500
1750
2000
2250
2500
2750
3000
3250
[RPM]
29,8
28,5
27
25,5
24
22,5

*04-45-C*

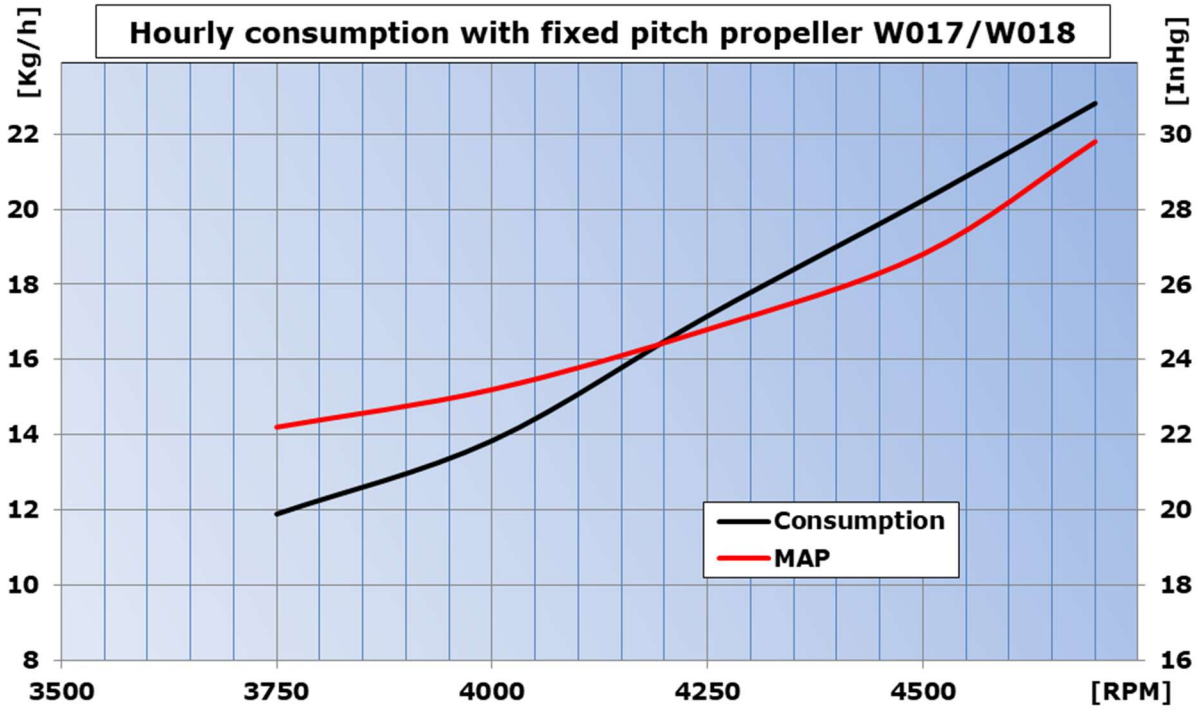

Hourly consumption at constant rev's W013/W014
[Kg/h]
20
18
16
14
12
10
8
6
4
22
23
24
25
26
27
28
29
[inHg]
3400
3250
3000
2750
2500
2250
2000
1750
1500

*04-46-C*

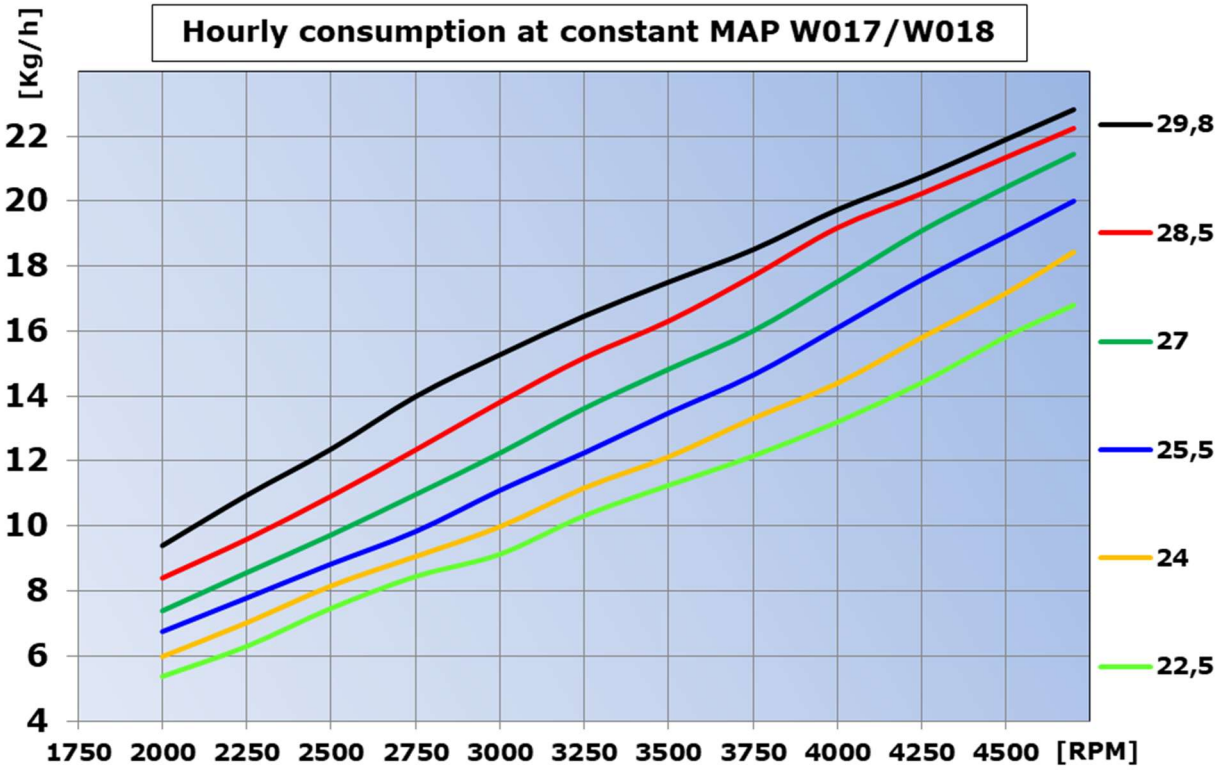
*04-03-03 Spirit 135 Direct R/L*



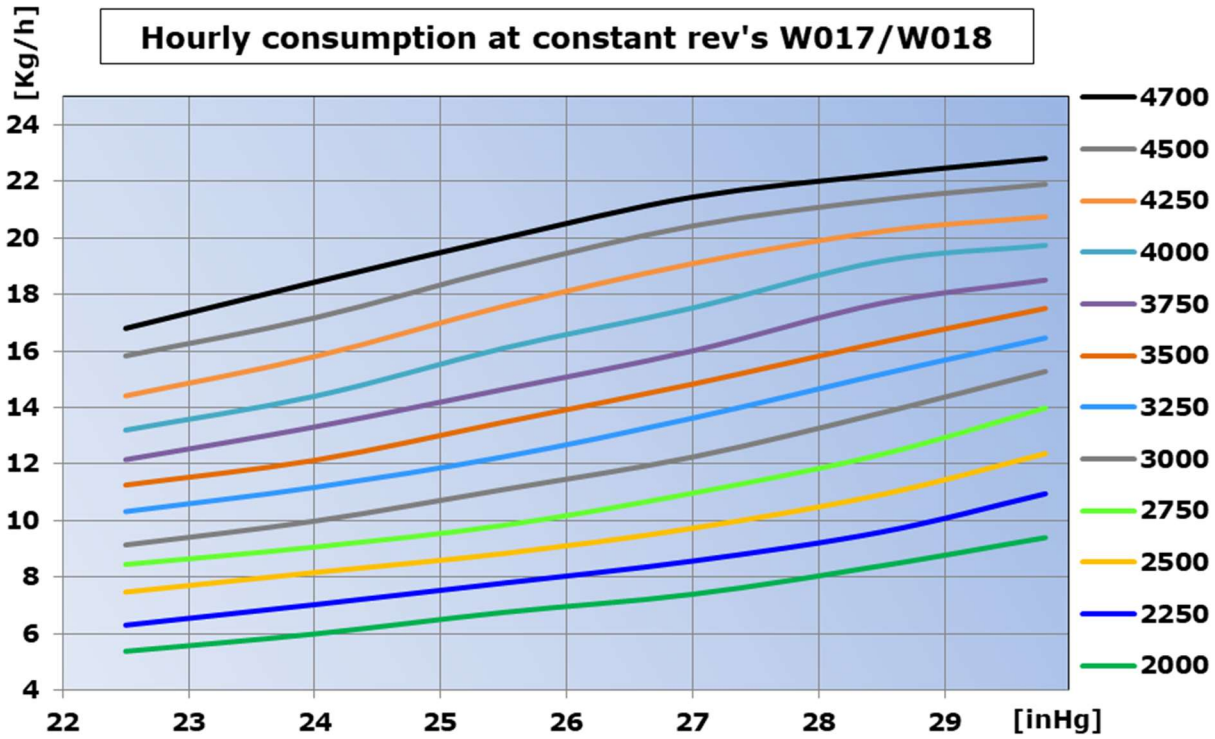

*04-47-C*




*04-48-C*

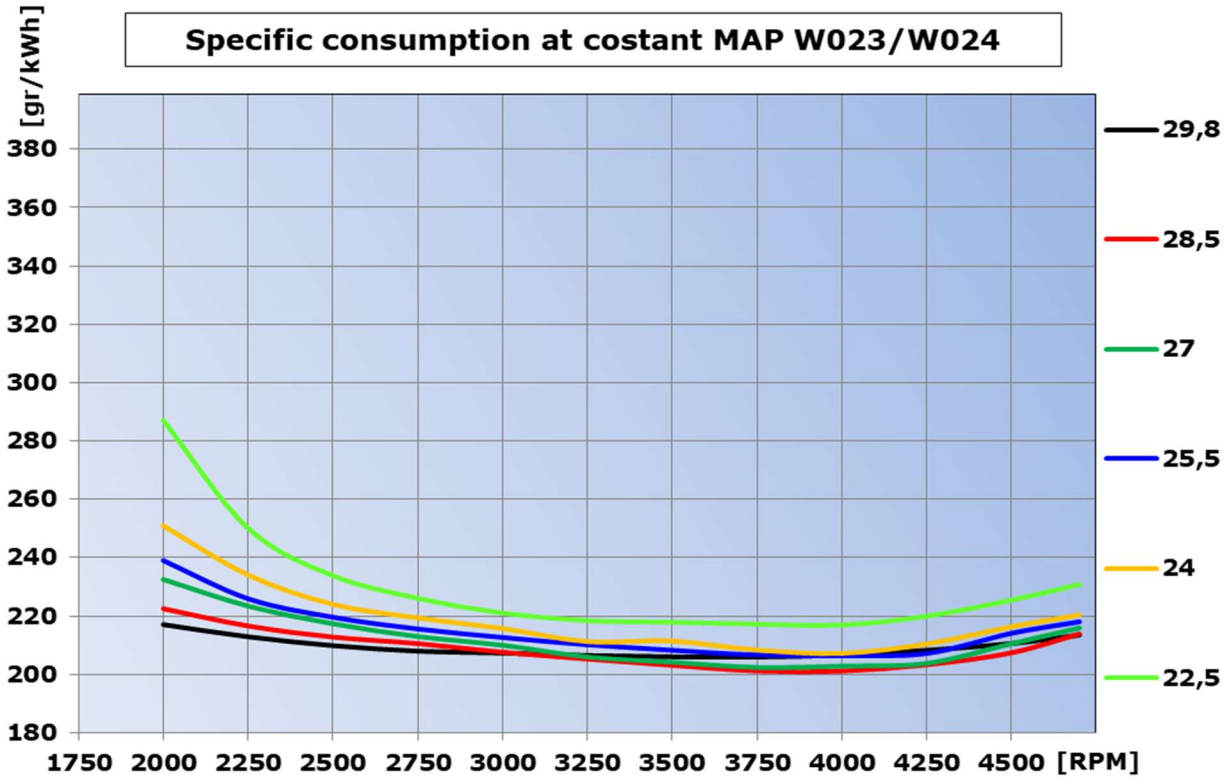

Hourly consumption at constant MAP W017/W018
[Kg/h]
22
20
18
16
14
12
10
8
6
4
1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 [RPM]
29,8
28,5
27
25,5
24
22,5

*04-49-C*

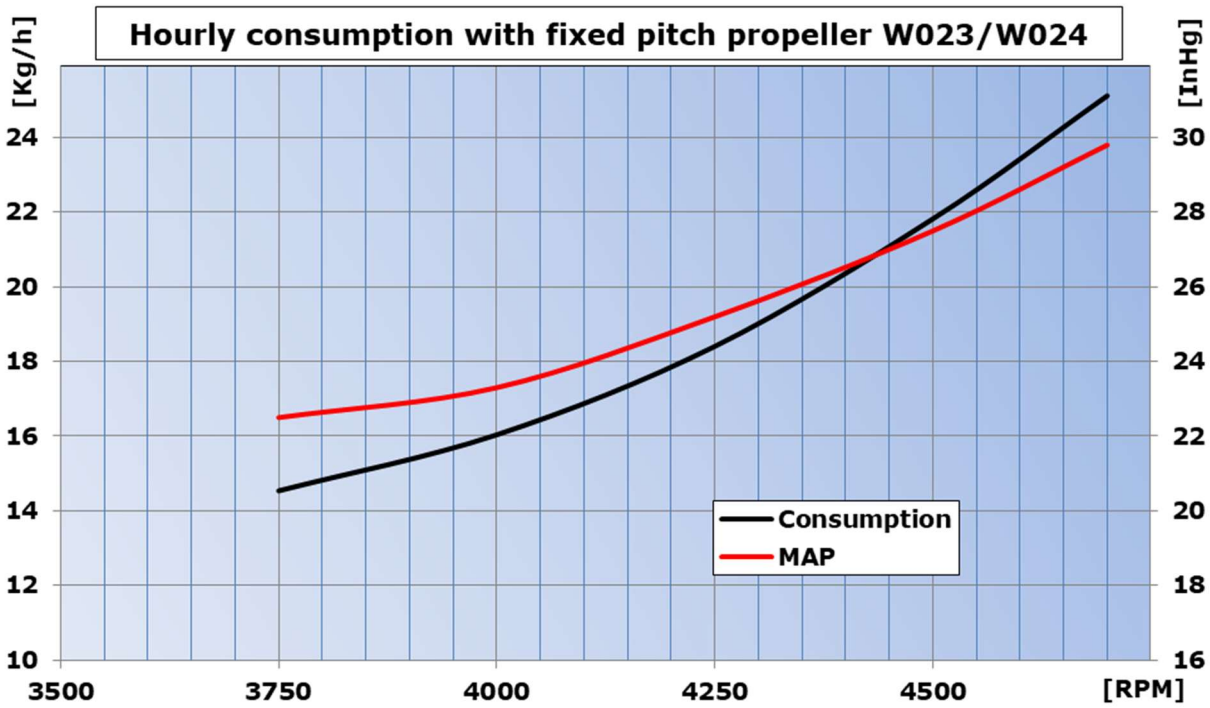

Hourly consumption at constant rev's W017/W018
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
22 23 24 25 26 27 28 29 [inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-50-C*

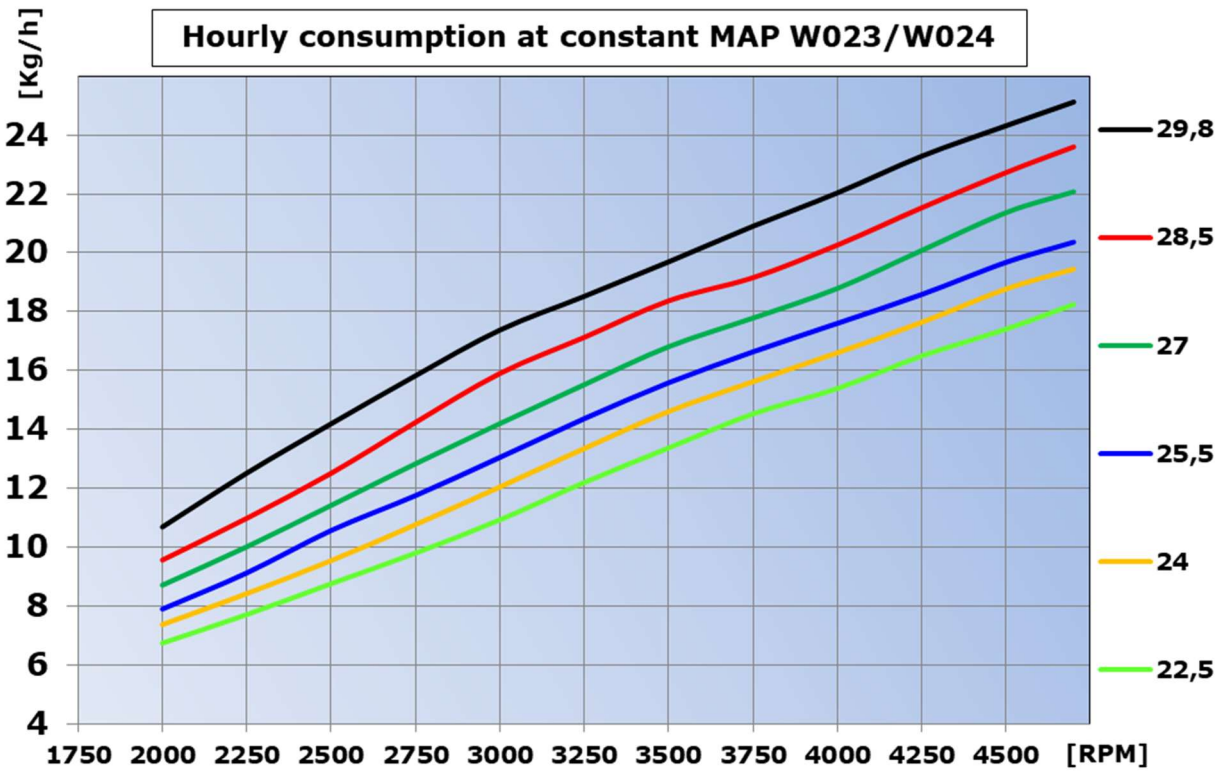
## 04-03-04 Spirit 160 Direct R/L



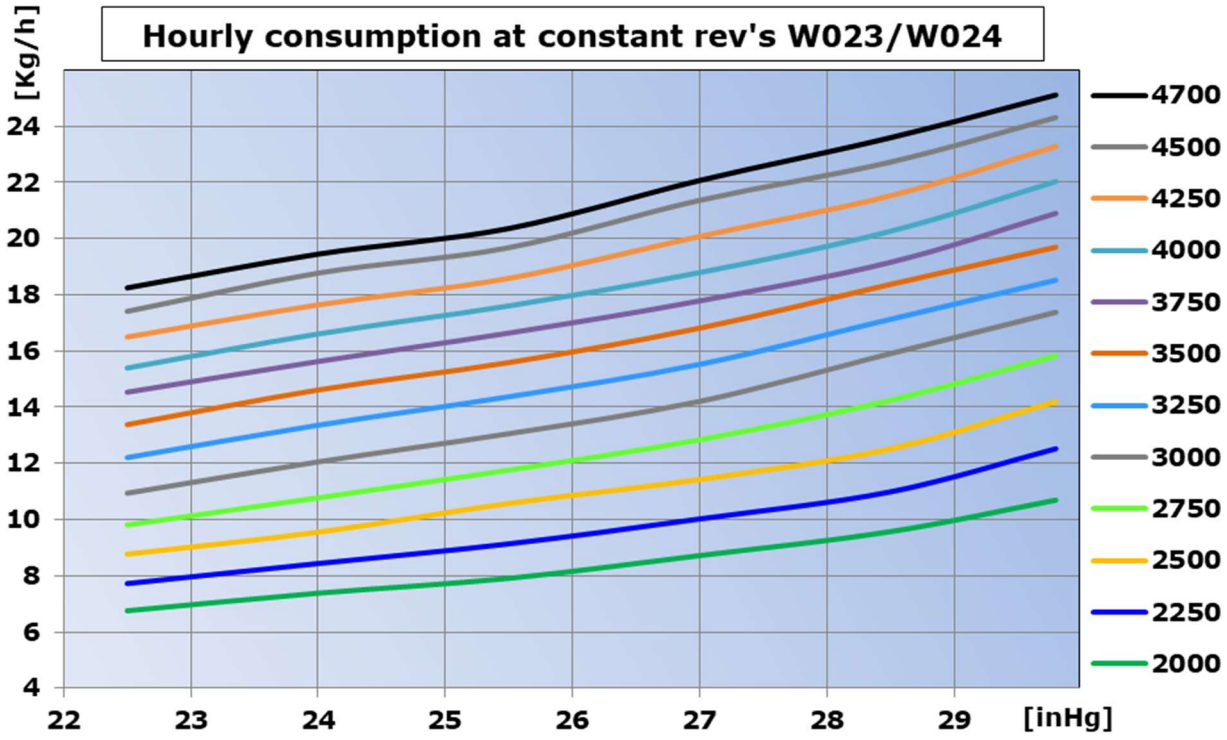

04-51-C




04-52-C

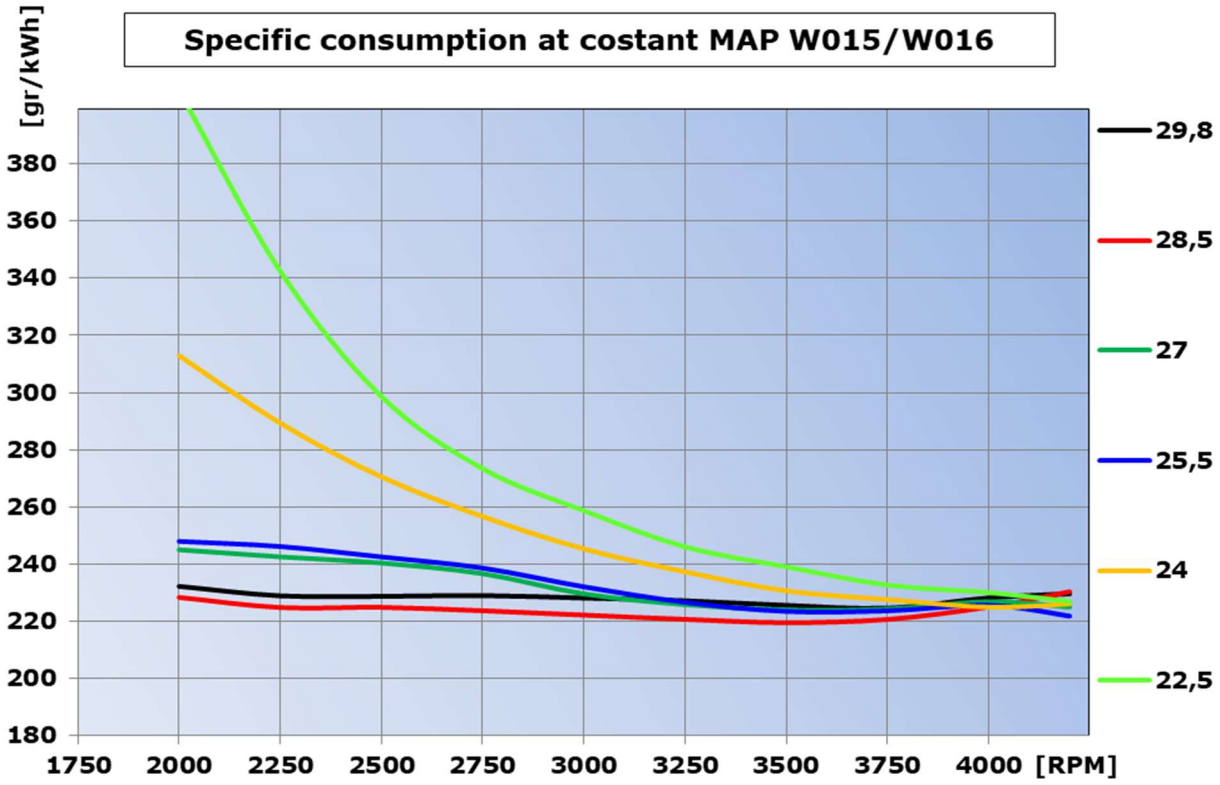

Hourly consumption at constant MAP W023/W024
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 [RPM]
29,8
28,5
27
25,5
24
22,5

*04-53-C*

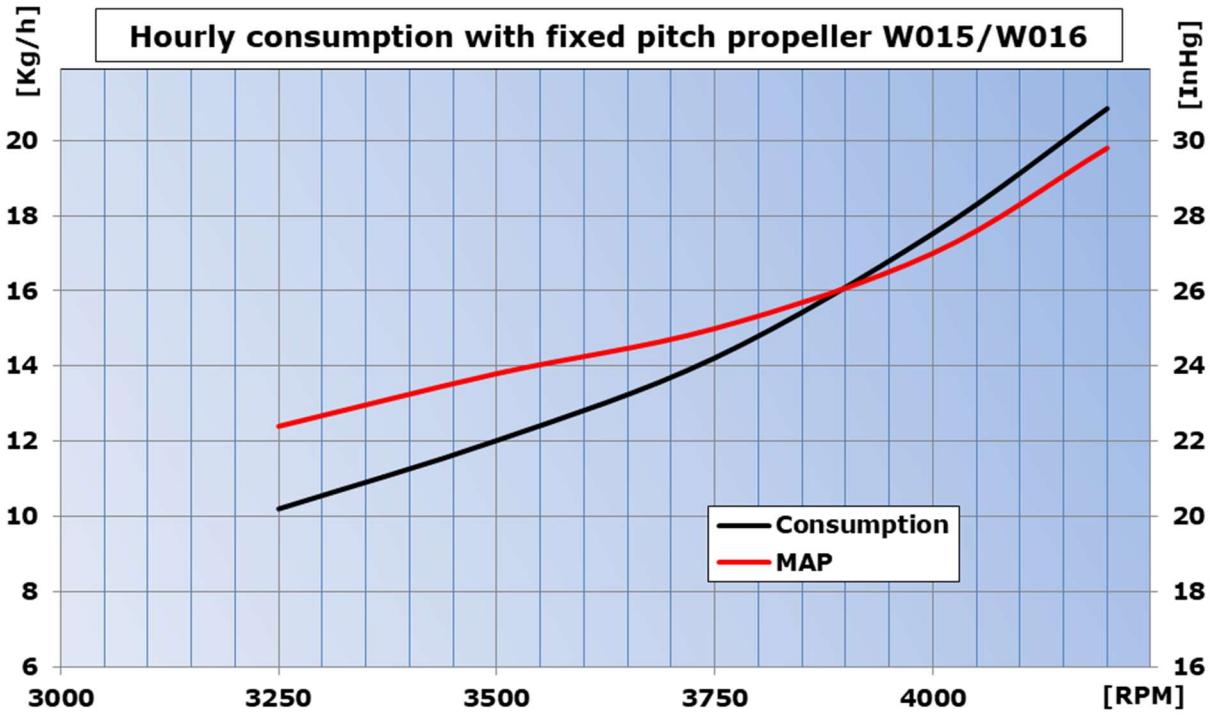

Hourly consumption at constant rev's W023/W024
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
22 23 24 25 26 27 28 29 [inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-54-C*

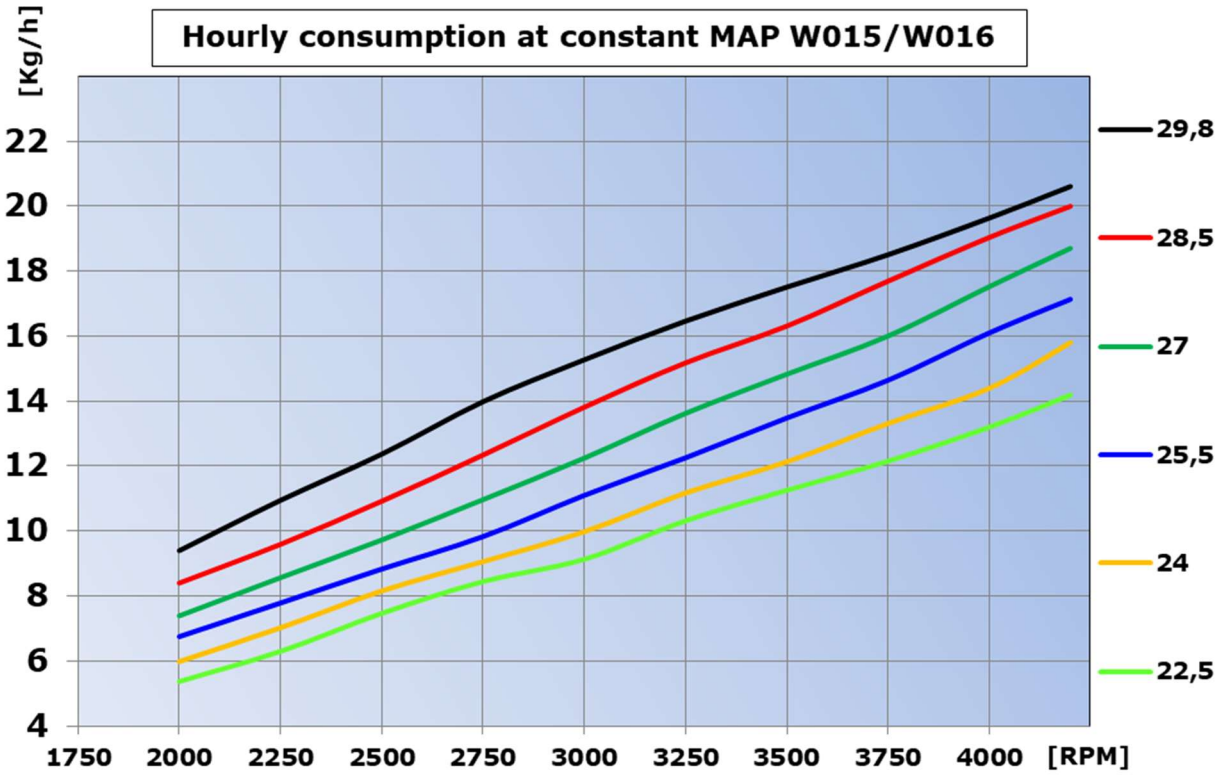
*04-03-05 Spirit 122 PSRU R/L*



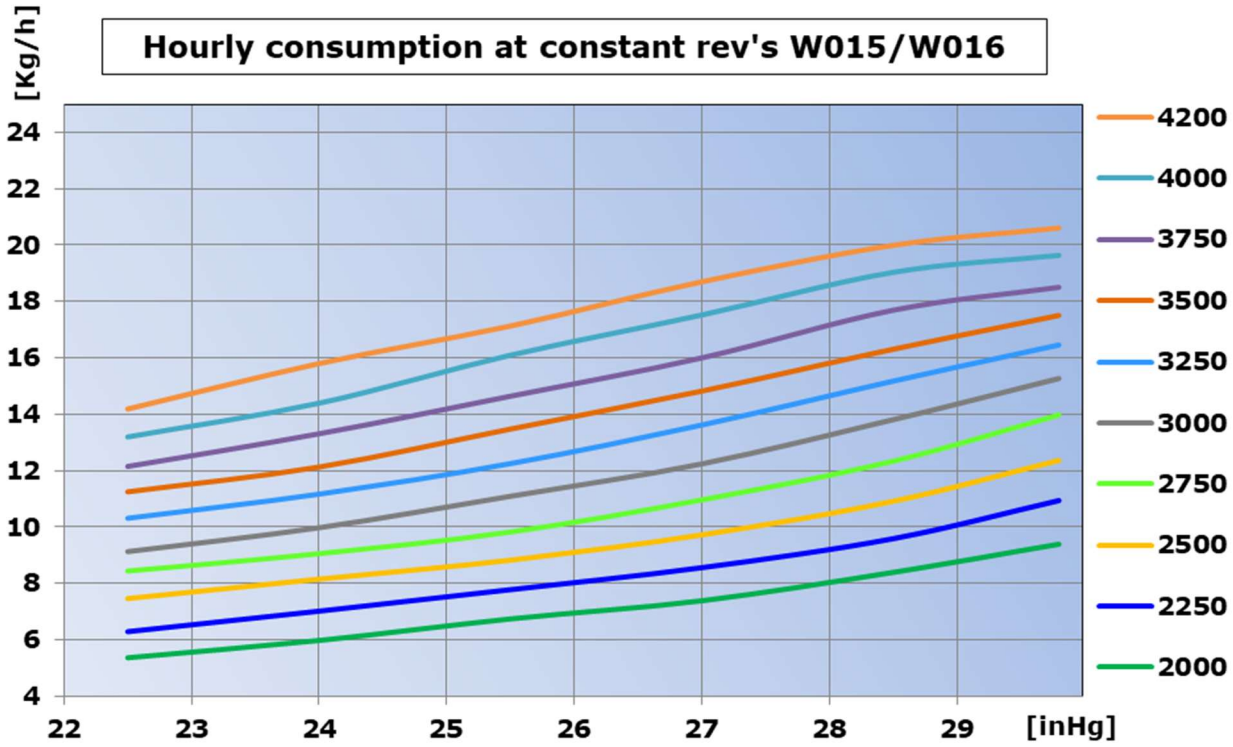

*04-55-C*




*04-56-C*

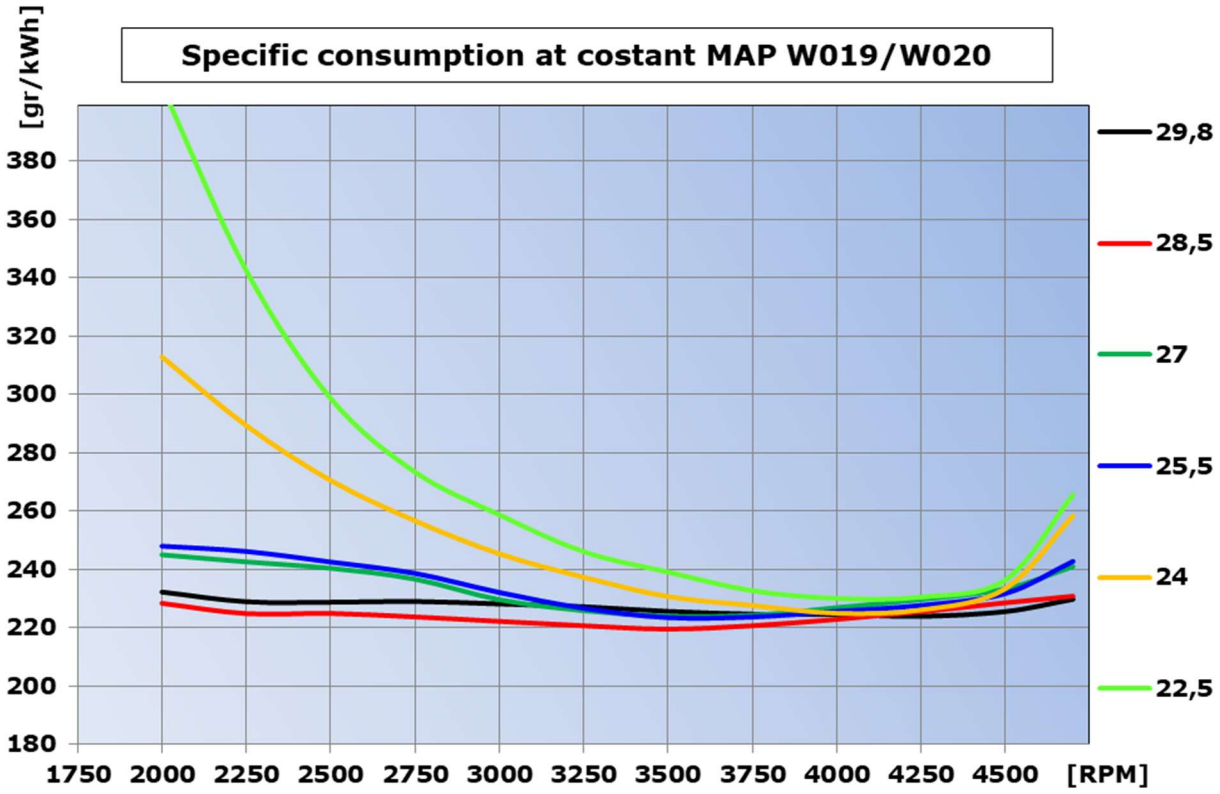

Hourly consumption at constant MAP W015/W016
[Kg/h]
22
20
18
16
14
12
10
8
6
4
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
[RPM]
29,8
28,5
27
25,5
24
22,5

*04-57-C*

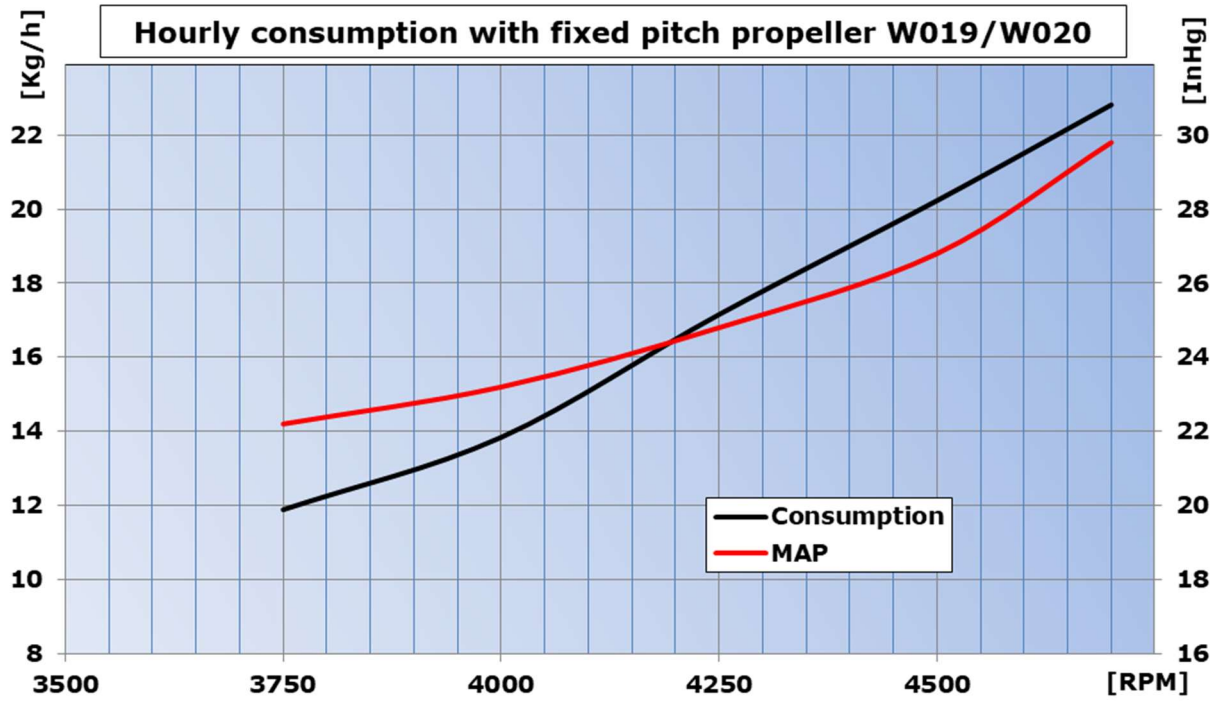

Hourly consumption at constant rev's W015/W016
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
22
23
24
25
26
27
28
29
[inHg]
4200
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-58-C*

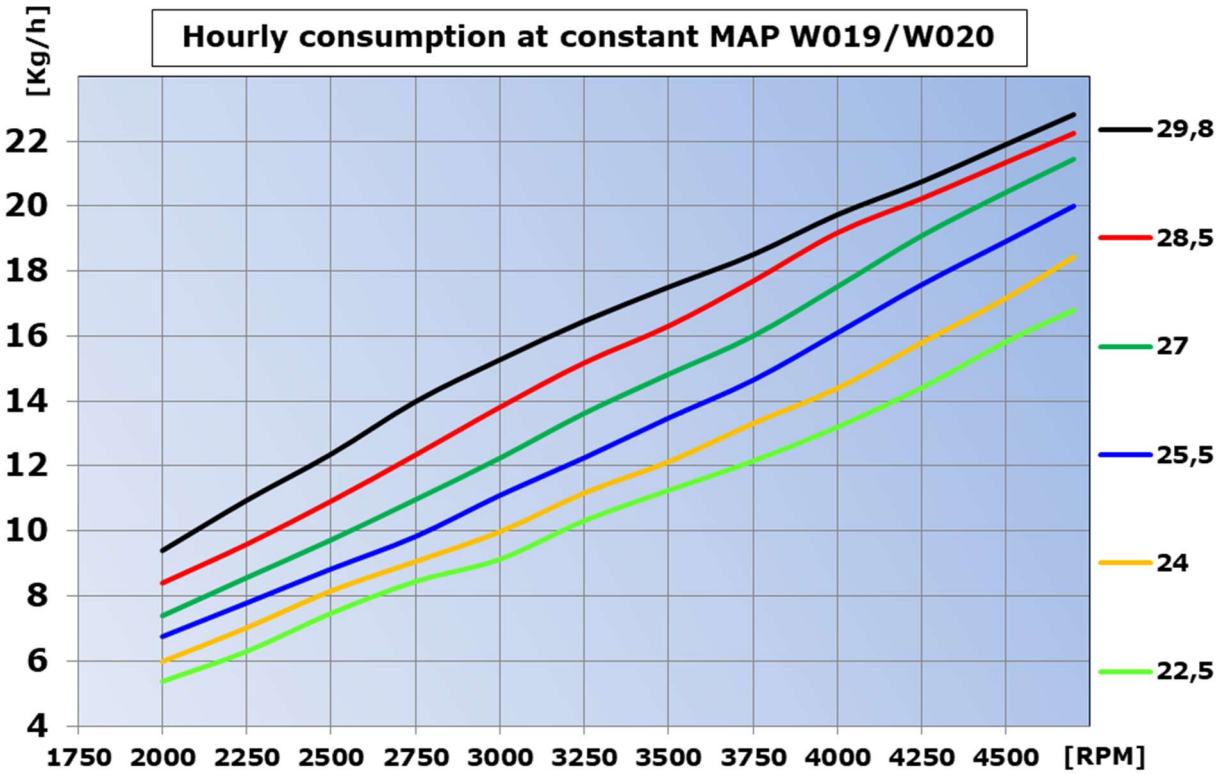
*04-03-06 Spirit 135 PSRU R/L*



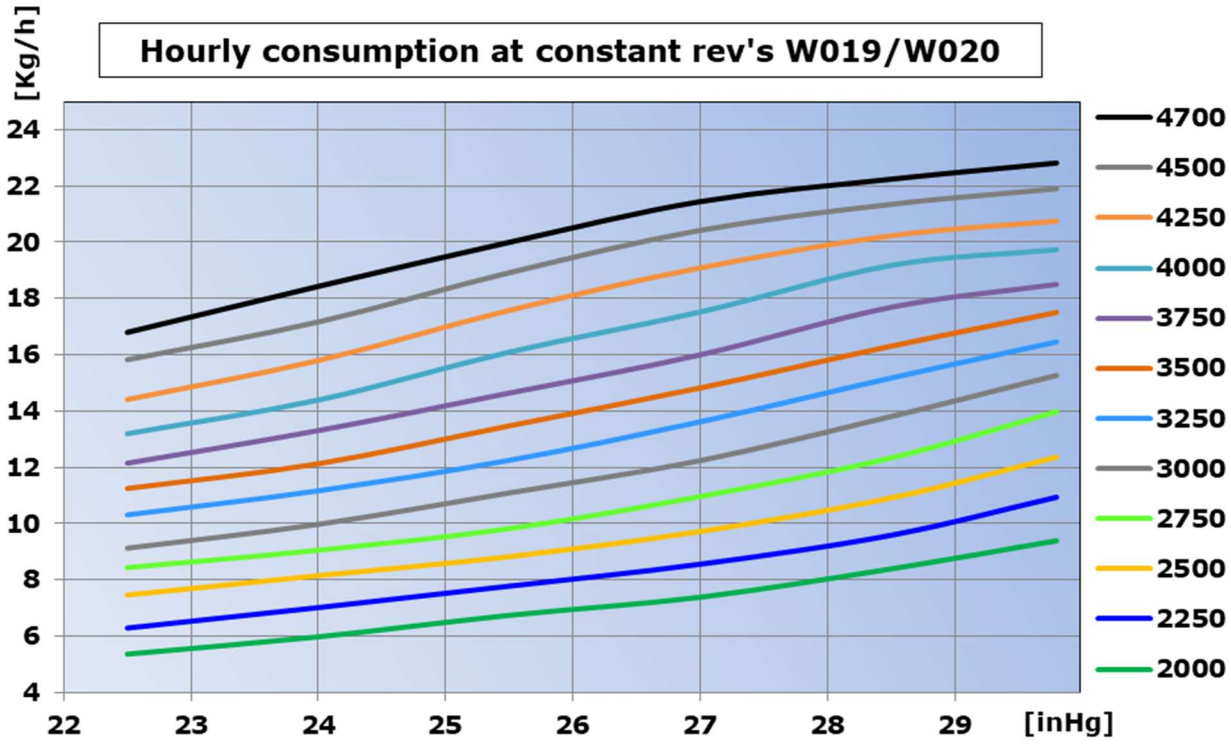

*04-59-C*




*04-60-C*

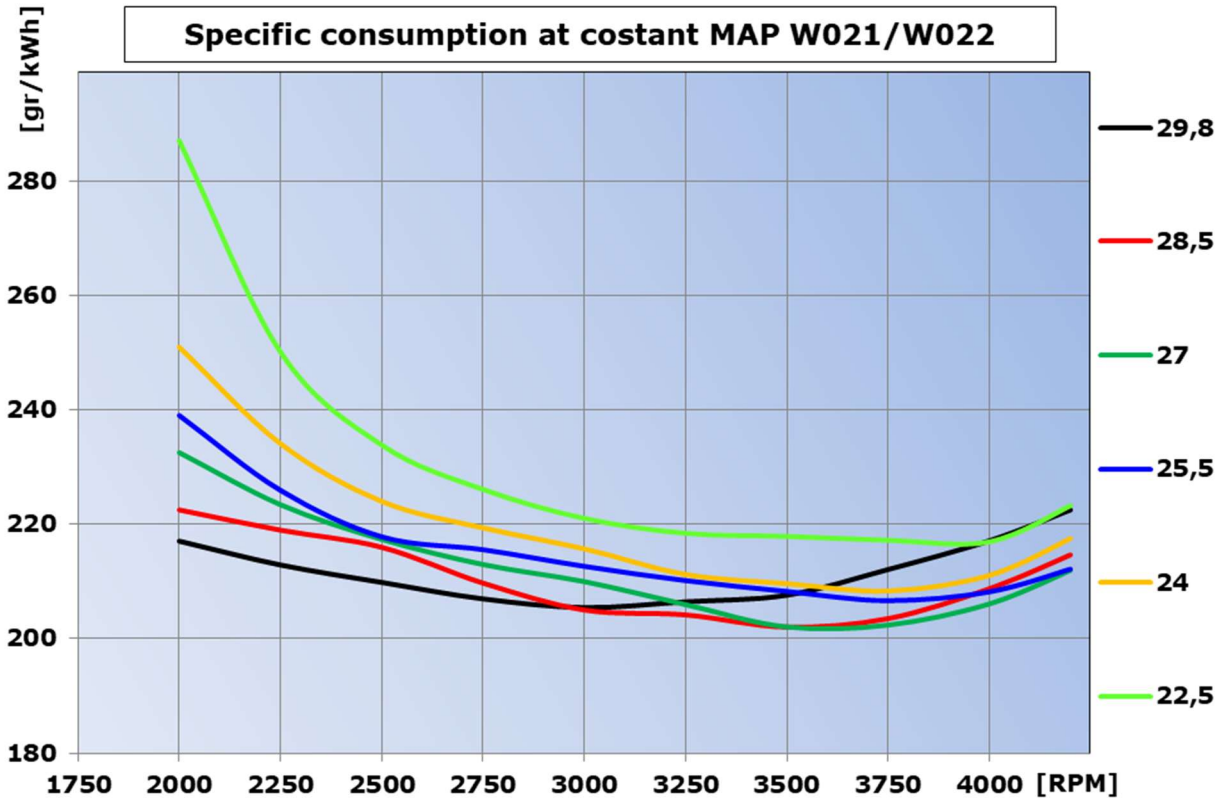

Hourly consumption at constant MAP W019/W020
[Kg/h]
22
20
18
16
14
12
10
8
6
4
1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 [RPM]
29,8
28,5
27
25,5
24
22,5

*04-61-C*

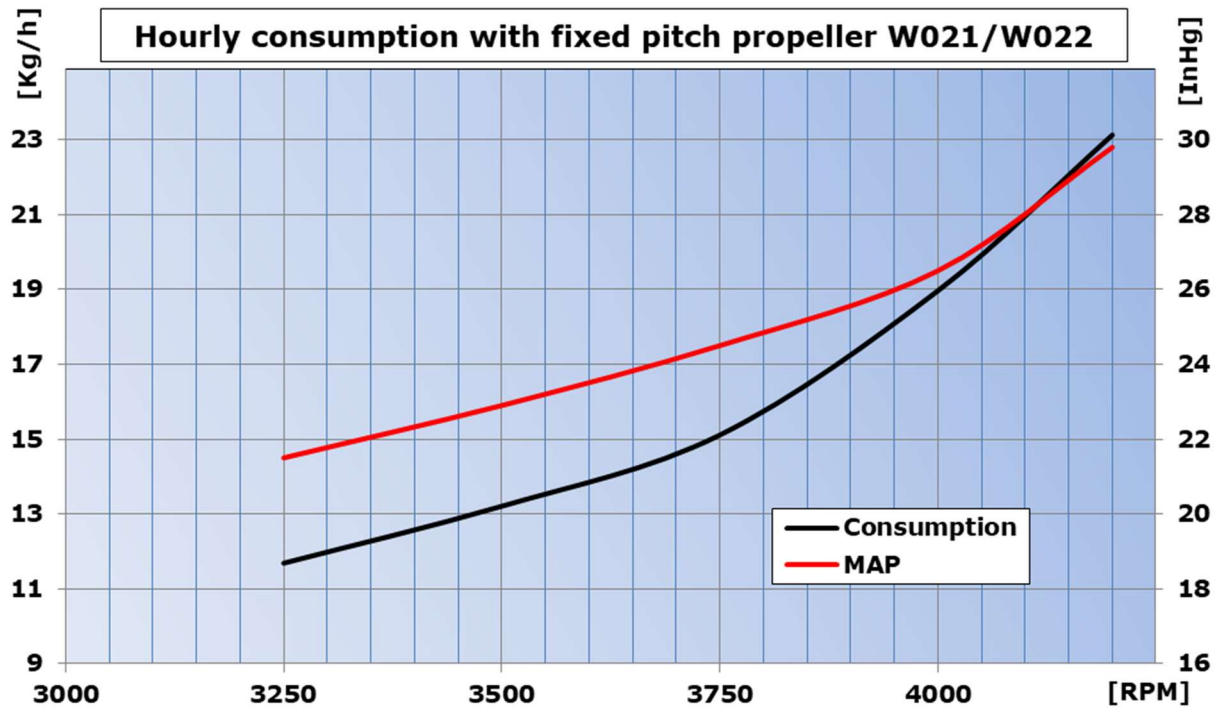

Hourly consumption at constant rev's W019/W020
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
22 23 24 25 26 27 28 29 [inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-62-C*

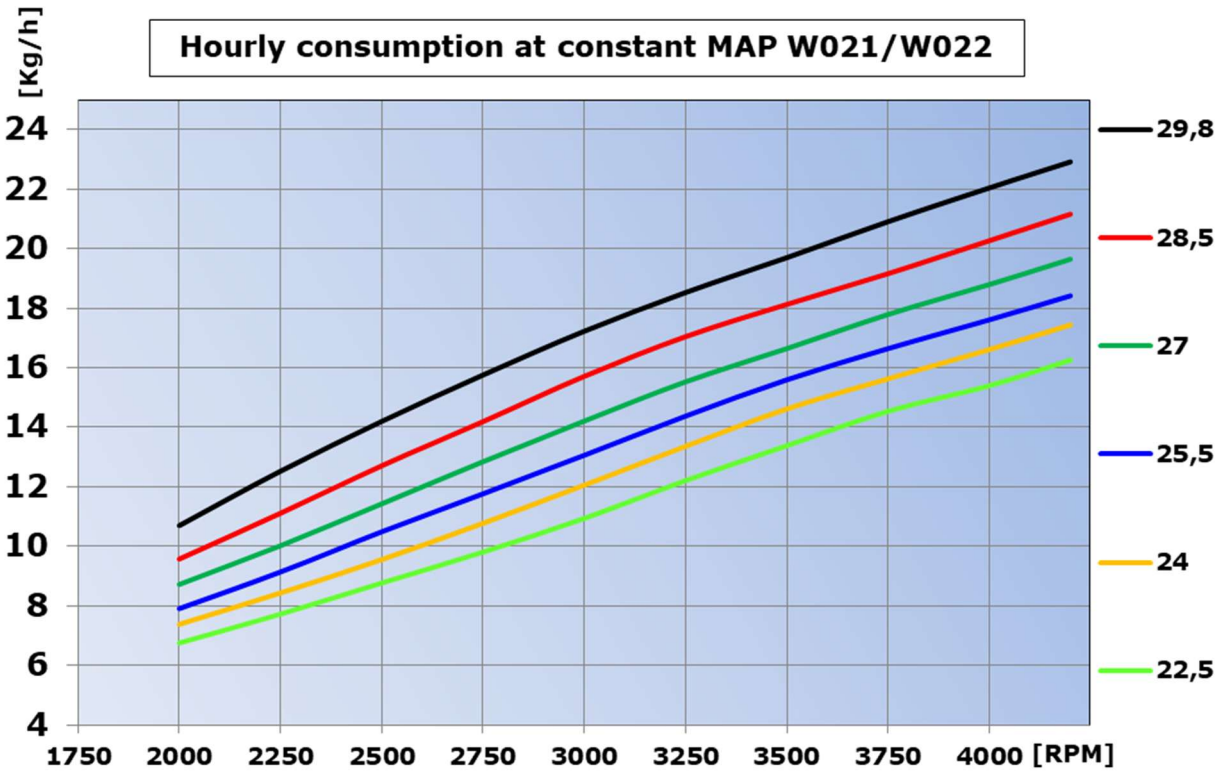
*04-03-07 Spirit 140 PSRU R/L*



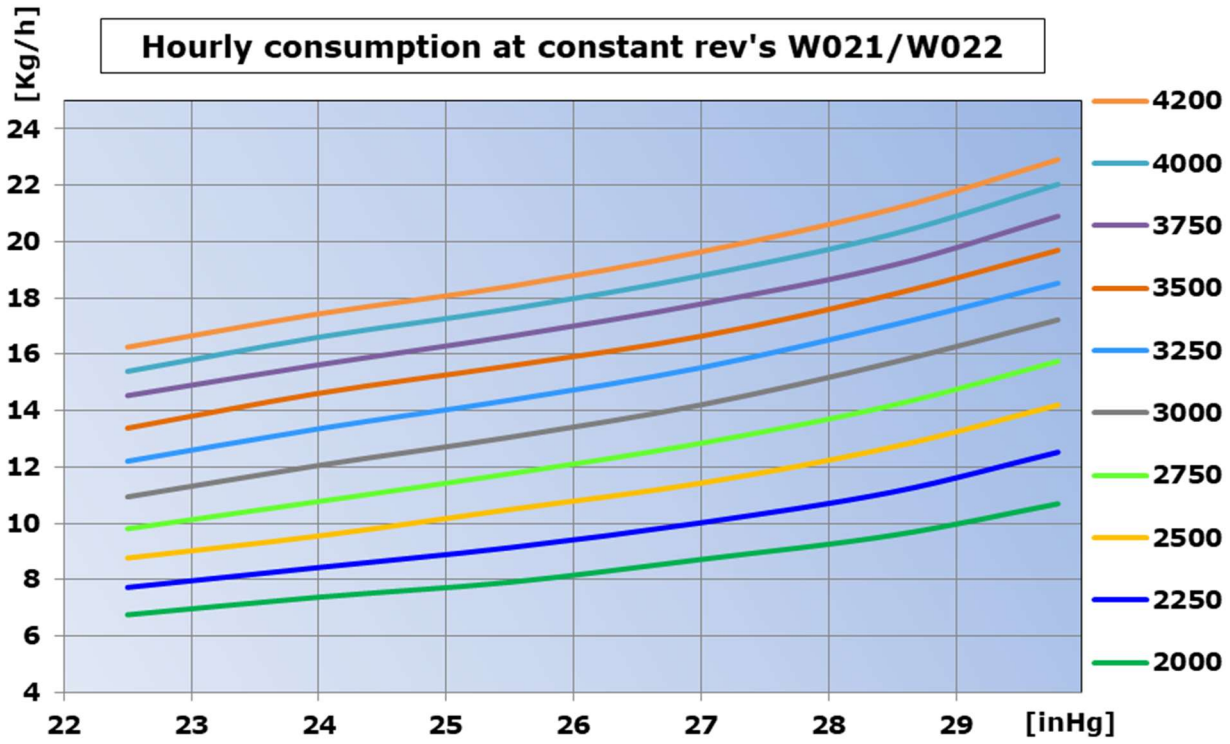

*04-63-C*




*04-64-C*

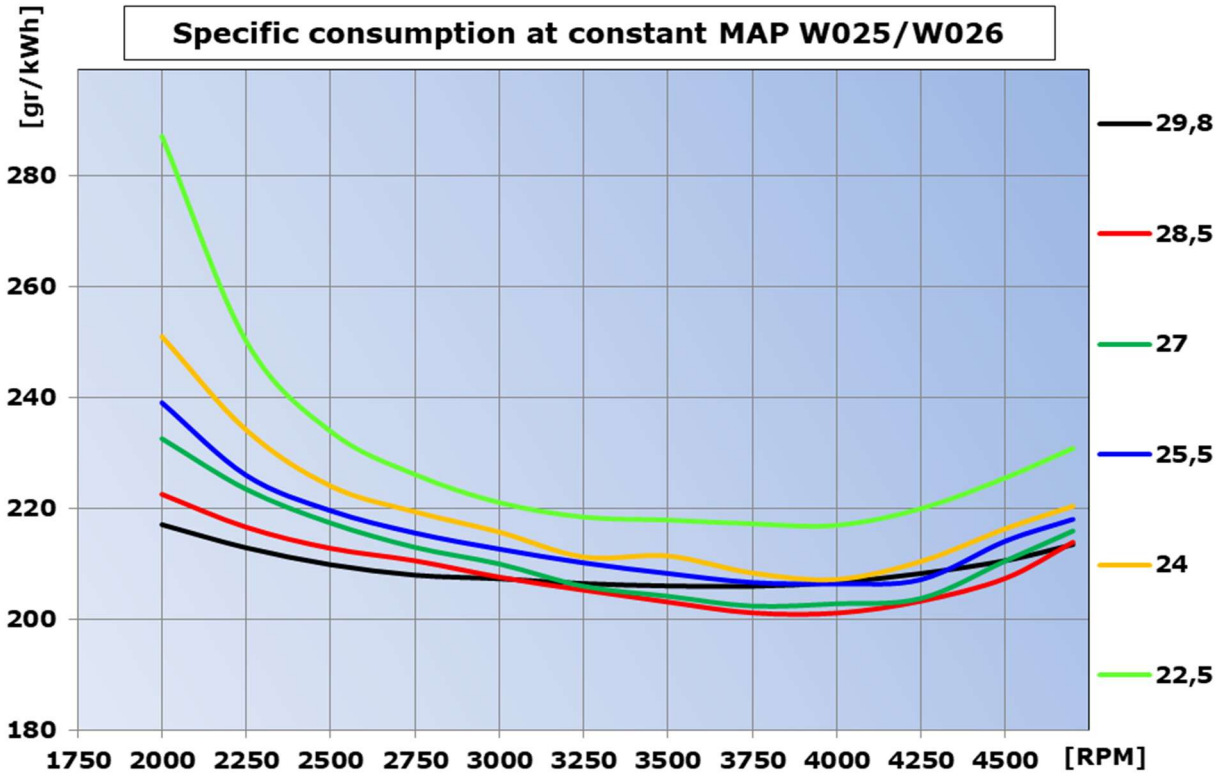

Hourly consumption at constant MAP W021/W022
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
[RPM]
29,8
28,5
27
25,5
24
22,5

*04-65-C*

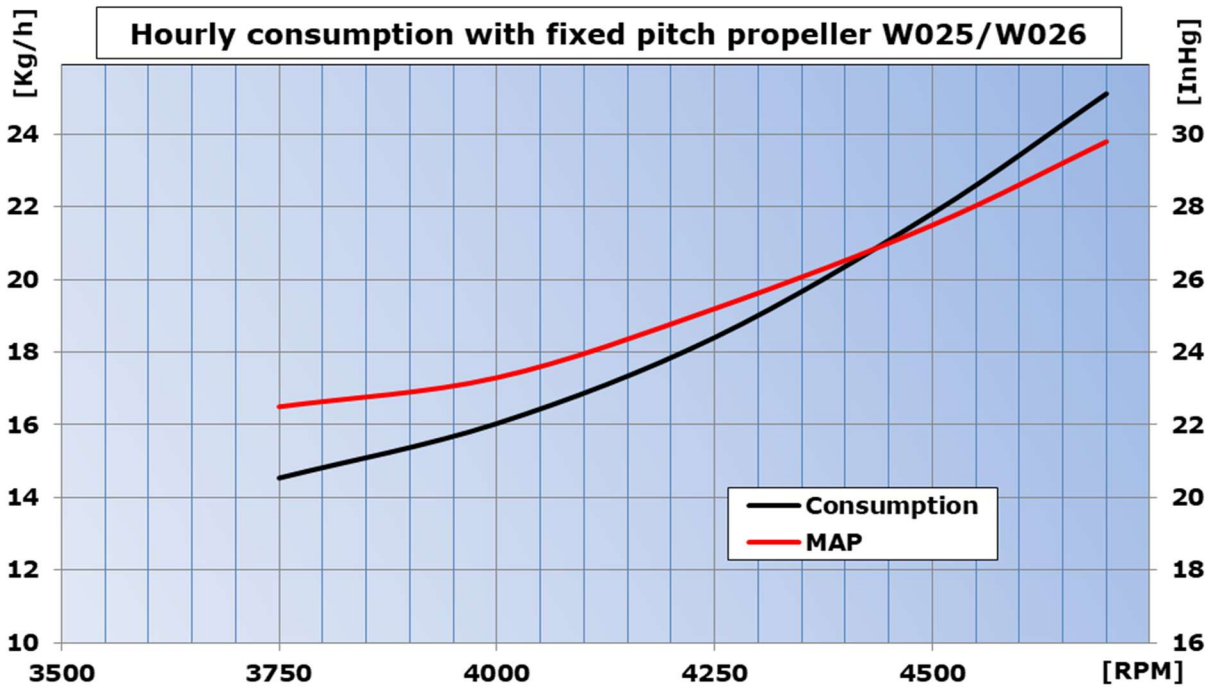

Hourly consumption at constant rev's W021/W022
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
22
23
24
25
26
27
28
29
[inHg]
4200
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-66-C*

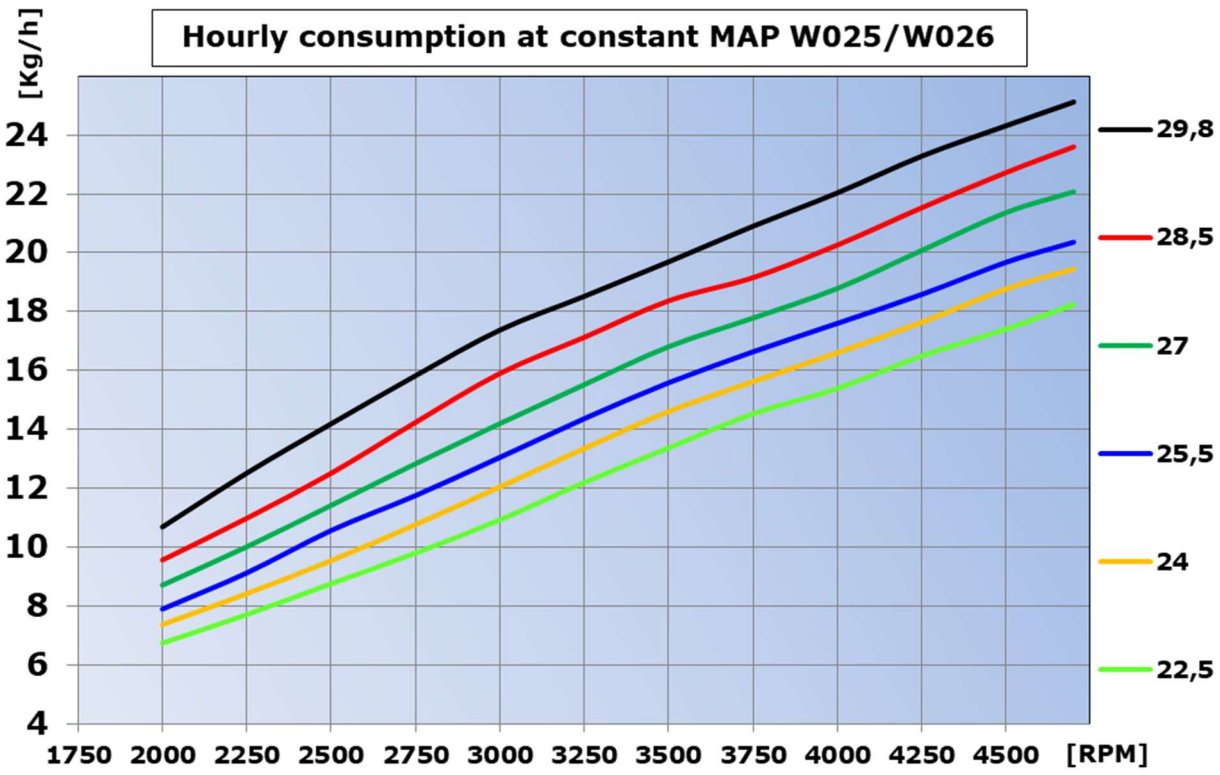
*04-03-08 Spirit 160 PSRU R/L*



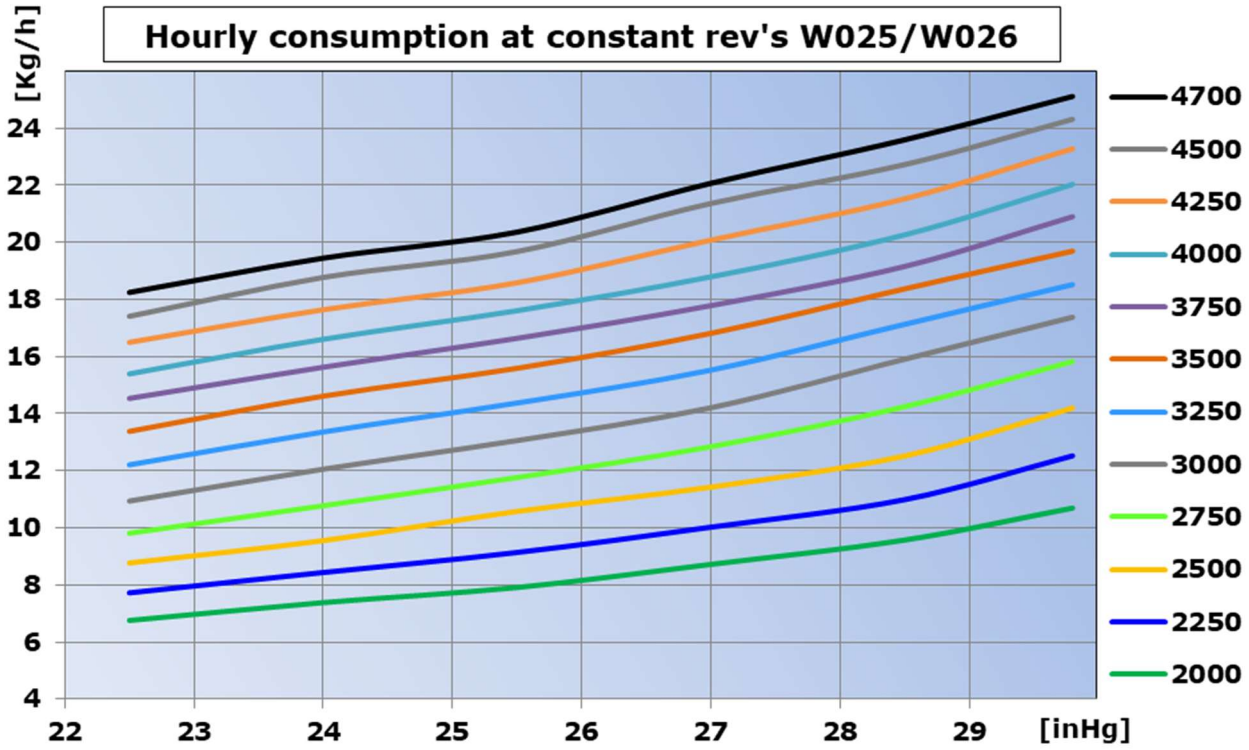

*04-67-C*




*04-68-C*


Hourly consumption at constant MAP W025/W026
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 [RPM]
29,8
28,5
27
25,5
24
22,5

*04-69-C*


Hourly consumption at constant rev's W025/W026
[Kg/h]
24
22
20
18
16
14
12
10
8
6
4
22 23 24 25 26 27 28 29 [inHg]
4700
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000

*04-70-C*

## 04-04 Lubricant consumption

Engine oil consumption is influenced by the operating conditions of the oil itself: higher temperatures, high rpm and low viscosity will cause higher consumption.

| Engine oil consumption | |
|---|---|
| | All versions |
| *Maximum consumption* | 0.5 liters every 10 hours |
| *Typical consumption* | 0.05 liters every 10 hours |

*04-71-C*

Likewise, the gear oil consumption is also influenced by the operating conditions.

| Gearbox oil consumption | |
|---|---|
| | All versions |
| *Maximum consumption* | 0.1 liter every 10 hours |
| *Typical consumption* | 0.01 liters every 10 hours |

*04-72-C*

A An oil consumption greater than the prescribed maximum is a symptom of probable mechanical failures or loss of lubricant: in this case it is necessary to carry out a careful inspection of the engine.

Lubricant must be topped up according to the prescriptions and quantities given in the installation manual.

## 04-05 Propeller RPM

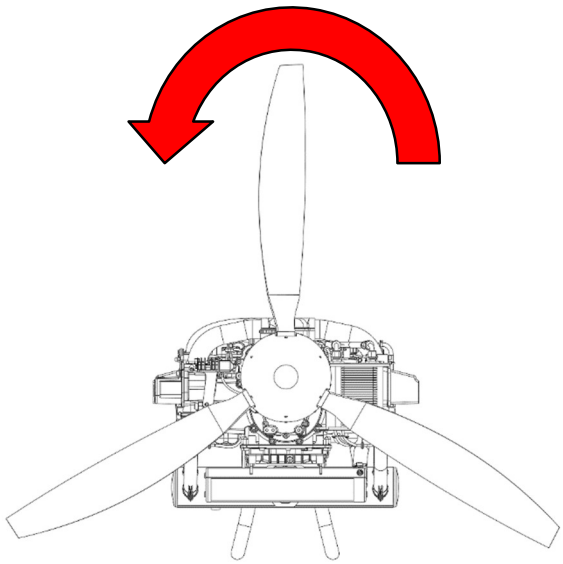
The maximum revolutions measured on the propeller shaft vary according to the engine model used. Below is a summary picture: the maximum revolutions shown, for engine and propeller, refer to the maximum speed of use; the over-rev threshold is in any case fixed above the maximum revs shown (consult table 72-11-C in the installation manual).

| Model | *Gear ratio* | *Max engine rpm per use [rpm]* | *Max prop rpm per use [rpm]* |
|---|---|---|---|
| Spirit 100 Direct R/L | 1÷1 | 3400 | 3400 |
| Spirit 115 Direct R/L | 1÷1 | 3400 | 3400 |
| Spirit 135 Direct R/L | 1÷1 | 4700 | 4700 |
| Spirit 160 Direct R/L | 1÷1 | 4700 | 4700 |
| Spirit 122 PSRU R/L | 1÷1,731 | 4200 | 2425 |
| Spirit 135 PSRU R/L | 1÷1,958 | 4700 | 2400 |
| Spirit 140 PSRU R/L | 1÷1,731 | 4200 | 2425 |
| Spirit 160 PSRU R/L | 1÷1,958 | 4700 | 2400 |

*04-73-C*

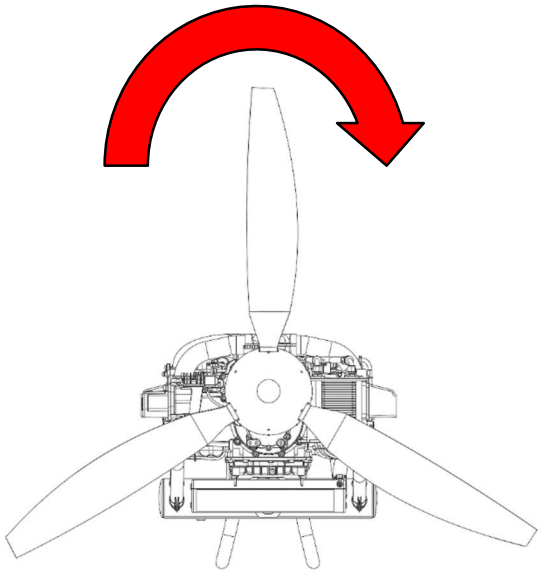
## 04-06 Propeller rotation direction

The direction of rotation of each engine version (both with reduction gear 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 makes a right rotation (right "R" engine), a propeller that moves in an anticlockwise direction makes a left rotation (left "L" engine).
For greater clarity, refer to the following figures.



*04-74-C*

*Counterclockwise rotation = left engine (L)*



*04-75-C*

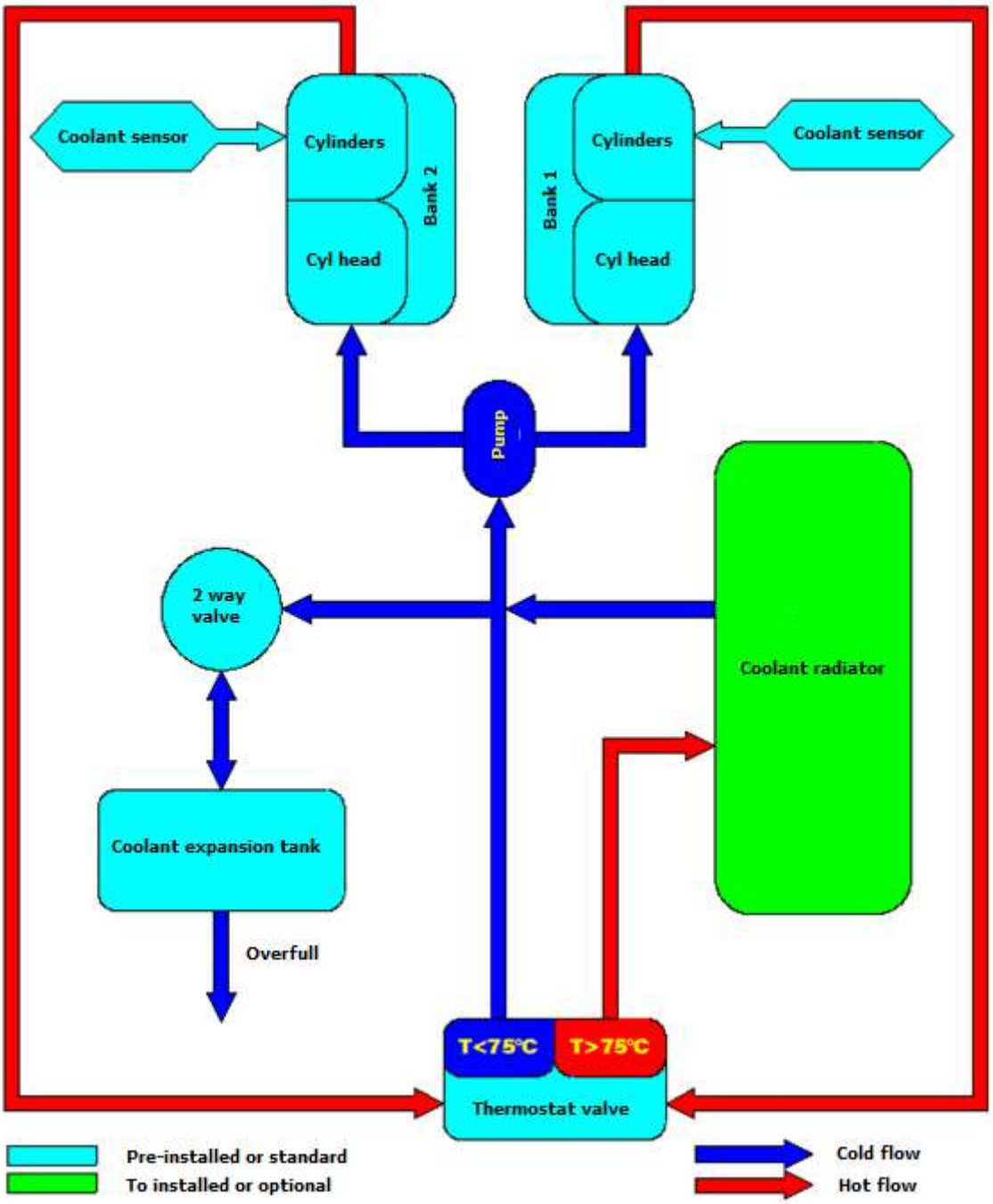
*Clockwise rotation = right engine (R)*

The propeller must not be rotated manually in the opposite direction to that of operation as this could damage the tensioning mechanism of the distribution chains and the starter disengagement system.

In right-hand rotation engines, the rotation of the propeller produces a leftward drift 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 versions with left rotation.

# 05 DESCRIPTION OF THE SYSTEMS

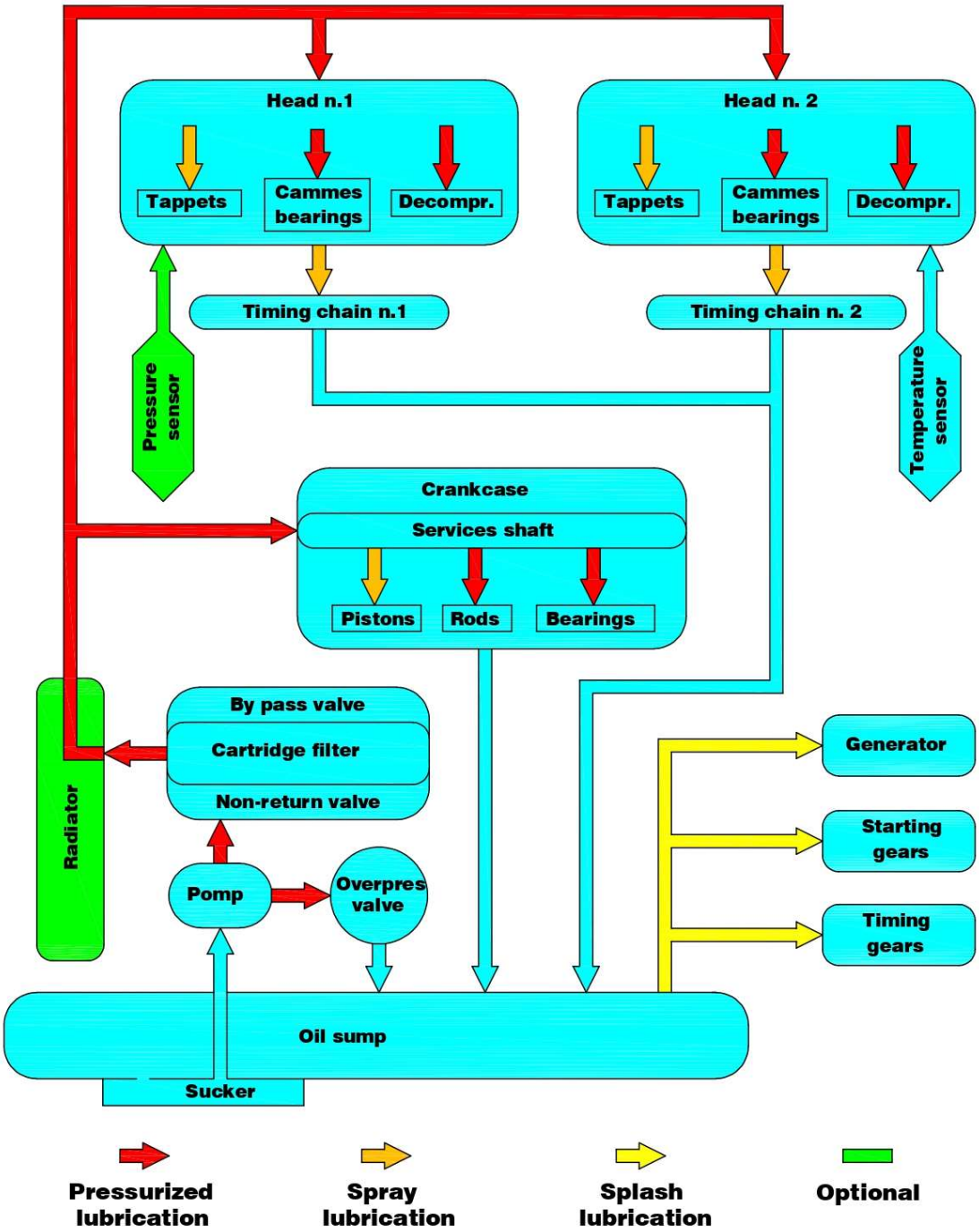
## 05-01 Cooling system




*05-01-C*

For a detailed description of the system, see the installation manual.
The coolant temperature is measured by two temperature probes, installed in each bank.

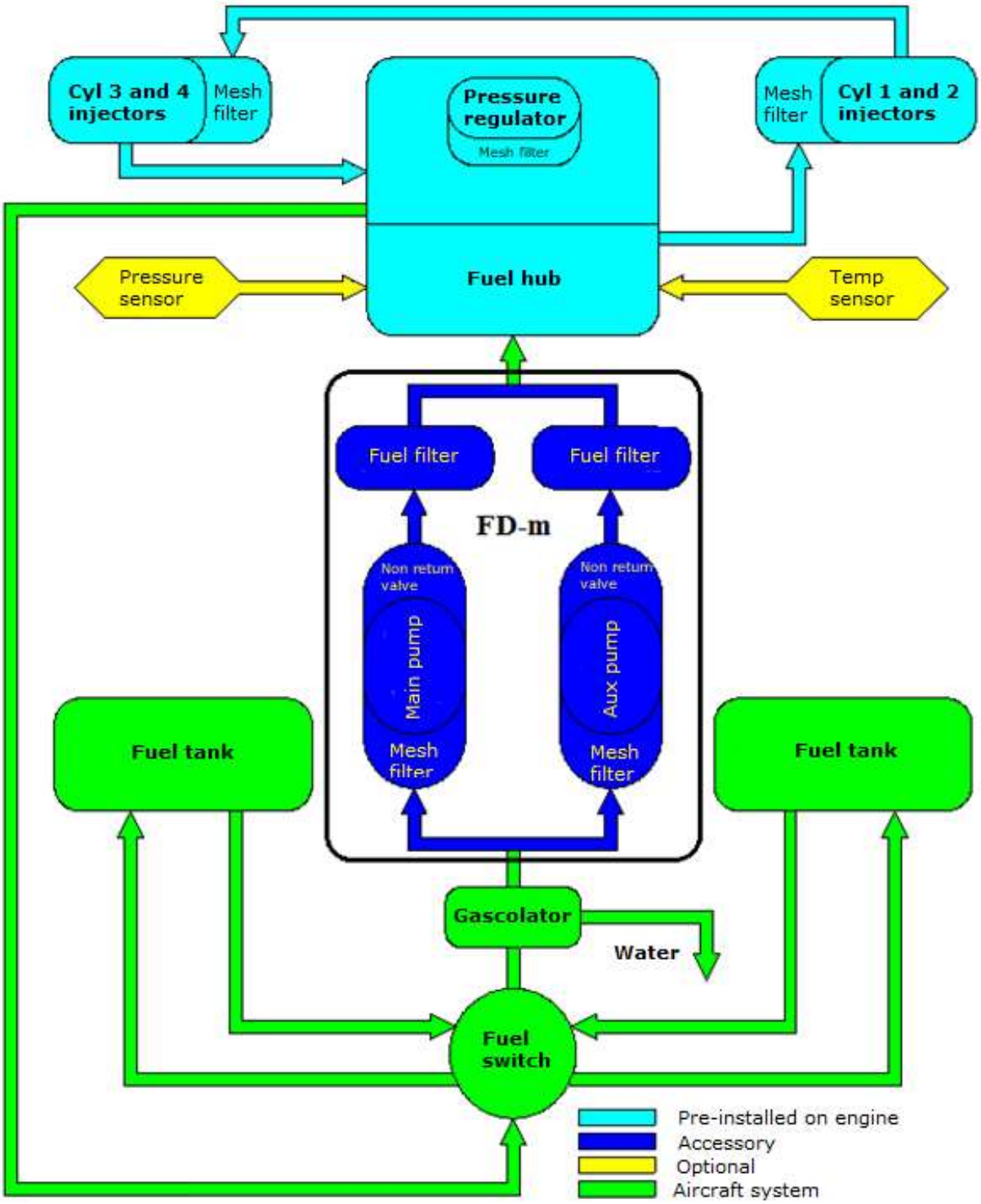
## 05-02 Lubrication system




*05-02-C*

For a detailed description of the system, see the installation manual.

## 05-03 Fuel system




*05-03-C*

For a detailed description of the system, see the installation manual.

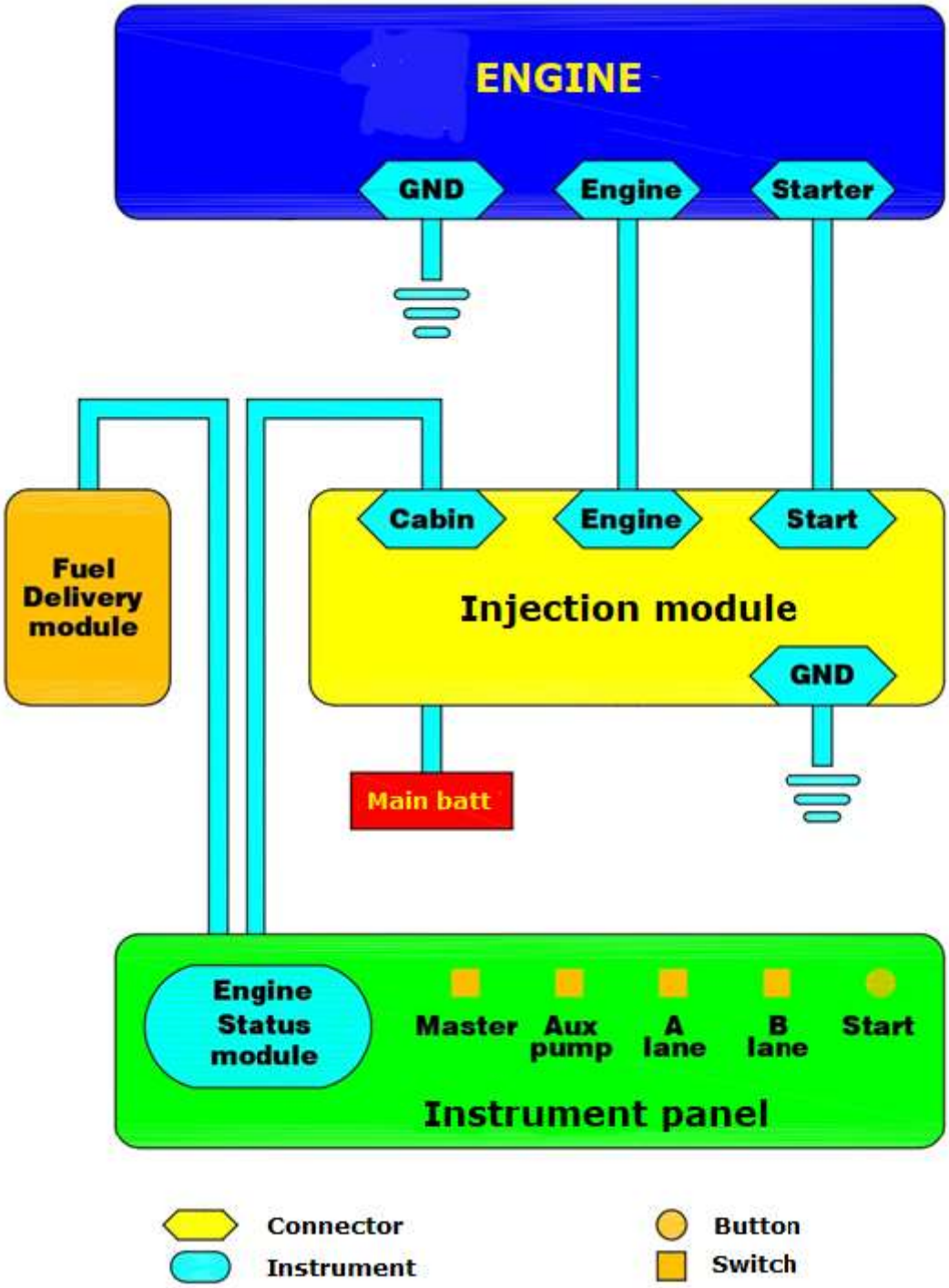
**If two tanks are used, it is essential to install a dual-flow valve, which can therefore operate both on the delivery branch and on the return branch to the tank.**

**If a safety valve is not installed, it is important to install a non-return valve on the fuel return branch to the tank, as close as possible to the tank itself: this valve serves to prevent, in the event of overturning or serious damage to the fuel system, that the fuel contained in the tanks can flow to the engine or to the cab.**

The fuel return line to the tanks is important to avoid the danger of vapor lock.

It is possible to measure both the temperature and the fuel pressure by mounting the appropriate sensors on the predispositions present on the fuel shunt.

## 05-04 Electrical system




*05-04-C*

The engine is equipped with two injection control units and mapped electronic ignition, with altimetric and barometric compensation and totally independent electrical circuits.
The electronic ignition system uses inductive discharge, with resistive shielding against radio interference.

The injection system is equipped with four high impedance injectors (2 per bank). Carburation is regulated by varying the opening time of the injectors.

The charging circuit consists of a 300 Watt push-pull winding generator, oil-cooled, and a 26 A current regulator.

If the engine is operated with the generator disconnected from the regulator, it is necessary to check and, if necessary, replace the generator itself.

By carrying out the electrical circuit according to the diagram defined in the installation manual, the engine can also operate with the battery disconnected or faulty: this is possible at speeds above approximately 1500 rpm, below which the current consumed by the fuel pump and by the of injection is higher than that produced by the recharging system.

In case of flight with battery disconnected from the system, it is necessary to implement the procedure described in paragraph 06-04-10: in this way the engine cannot drop below the switch-off speed.

### *05-04-01 EM-m instrument*

The EM-m instrument can be installed in a very simple way, as an accessory, making a decisive contribution to flight safety, since it allows you to have the operating status of the engine and the injection control units under control; the instrument also records the value of all engine operating parameters (rpm, temperatures, pressures, operating hours and more), and allows them to be exported in CAN Aerospace format, making it very easy to connect additional instruments to the system.

The instrument can also be configured as a navigation instrument, with GPS and artificial horizon: to find out the list of functions and the correct way of use, consult the respective user manuals.

Do not perform flights or ground tests before having read and understood the instrument user manual.

Do not start the engine before having electrically connected the instrument to the wiring, as the system would detect the event as an anomaly.

# 06 OPERATING INSTRUCTIONS

## 06-01 General operating limits

### *06-01-01 Engine revolutions*

| **Maximum revolutions [rpm]** | *Maximum Power* | *Overspeed Threshold* |
|---|---|---|
| *Spirit 100 Direct R/L* | 3400 | **3500** |
| *Spirit 115 Direct R/L* | 3400 | **3500** |
| *Spirit 122 PSRU R/L* | 4200 | **4250** |
| *Spirit 135 Direct R/L* | 4700 | **4750** |
| *Spirit 135 PSRU R/L* | 4700 | **4750** |
| *Spirit 140 PSRU R/L* | 4200 | **4250** |
| *Spirit 160 Direct R/L* | 4700 | **4750** |
| *Spirit 160 PSRU R/L* | 4700 | **4750** |

*06-01-C*

A

Exceeding the maximum permissible revolutions represents a condition of potential risk for the integrity of the engine, and must be prevented by using propellers with characteristics suitable for the power supplied.

The following tables show the engine revolutions corresponding to the various percentages of power in the case of installations with a fixed-pitch propeller, in which it is assumed that the propeller reaches and does not exceed the maximum power regime in flight.

| Spirit Skyline versions | | | | |
|---|---|---|---|---|
| **Engine revolutions [rpm]** | 100 Direct R/L | 135 Direct R/L | 122 PSRU R/L | 140 PSRU R/L |
| *On takeoff (max for 5 minutes)* | 3400 | 4700 | 4200 | 4200 |
| *Maximum continuous power* | 3400 | 4520* | 4050* | 4050* |
| *At 95% power* | 3340 | 4620 | 4130 | 4130 |
| *At 90% power* | 3280 | 4540 | 4050 | 4050 |
| *At 85% power* | 3220 | 4450 | 3980 | 3980 |
| *At 80% power* | 3150 | 4360 | 3900 | 3900 |
| *At 75% power* | 3090 | 4270 | 3820 | 3820 |
| *At 70% power* | 3020 | 4170 | 3730 | 3730 |
| *At 65% power* | 2950 | 4070 | 3640 | 3640 |
| *At 60% power* | 2870 | 3960 | 3540 | 3540 |
| *At 55% power* | 2790 | 3850 | 3440 | 3440 |
| *At 50% power* | 2700 | 3730 | 3330 | 3330 |
| *Idle* | 750÷1000 | 1500÷1700 | 950÷1200 | 950÷1200 |

*06-02-C*

| Spirit Redline versions | | | | |
|---|---|---|---|---|
| **Engine revolutions [rpm]** | 115 Direct R/L | 160 Direct R/L | 135 PSRU R/L | 160 PSRU R/L |
| *On takeoff (max for 5 minutes)* | 3400 | 4700 | 4700 | 4700 |
| *Maximum continuous power* | 3400 | 4520* | 4450* | 4460* |
| *At 95% power* | 3340 | 4620 | 4620 | 4620 |
| *At 90% power* | 3280 | 4540 | 4540 | 4540 |
| *At 85% power* | 3220 | 4450 | 4450 | 4450 |
| *At 80% power* | 3150 | 4360 | 4360 | 4360 |
| *At 75% power* | 3090 | 4270 | 4270 | 4270 |
| *At 70% power* | 3020 | 4170 | 4170 | 4170 |
| *At 65% power* | 2950 | 4070 | 4070 | 4070 |
| *At 60% power* | 2870 | 3960 | 3960 | 3960 |
| *At 55% power* | 2790 | 3850 | 3850 | 3850 |
| *At 50% power* | 2700 | 3730 | 3730 | 3730 |
| *Idle* | 750-1000 | 1500-1700 | 950-1200 | 950-1200 |

*06-03-C*

* In the case of installations with a variable pitch propeller, the maximum continuous power can also be reached at speeds different from that indicated, provided that the supply pressure limit (MAP) is respected, as indicated in paragraph 06-01-04 of this manual.

## *06-01-02 Fuel pressure*

| **Fuel pressure [bar]** | **All versions** |
|---|---|
| *Maximum* | 3.6 |
| *Minimum* | 3.0 |
| *Max variation with auxiliary pump* | 0.4 |

*06-04-C*

**In the event of pressures above or below the values indicated, the engine runs irregularly. Do not use it in flight until the problem is identified and resolved.**

It is necessary to monitor the fuel pressure and electrical absorption during the flight, to detect any anomalies that may compromise safety.

If the FD-m is not used, it is still recommended to install an auxiliary fuel pump, to be used in the event of main fuel pump failure in flight or in critical flight conditions for safety (take-off and landing).

## *06-01-03 Engine oil pressure*

| **Engine oil pressure [bar]** | **All versions** |
|---|---|
| *Maximum in flight* | 4.5 |
| *Minimum in flight* | 1.5 |
| *Normal in flight* | 2.5 |
| *Idling below 2200 rpm* | 0.8 |

*06-05-C*

It is necessary to keep the engine oil pressure under observation during the flight, to detect any anomalies that could compromise safety.

### *06-01-04 Manifold Pressure (MAP)*

Maximum continuous supply pressure cannot exceed 28.5 in/Hg, corresponding to 965 mBar.
To allow reaching the maximum power, this value can be exceeded for a maximum of 5 continuous minutes; between one overrun and the next you need to wait at least 5 minutes.

If the 5 minute limit is exceeded, the event is logged in the ECUs.

### *06-01-05 Engine oil temperature*

| Engine oil temperature [°C] | All versions |
|---|---|
| *Maximum* | 130 |
| *Minimum in flight* | 50 |
| *Typical* | 100 |

*06-06-C*

The temperature of the lubricant is an important index of the thermal state of the engine, and, more than the temperature of the coolant, must be considered for heating purposes.

It is necessary to keep the temperature of the lubricant under observation during the flight, to detect any anomalies that could compromise safety.

### *06-01-06 Gearbox oil temperature*

The reduction gear oil temperature is not normally detected by any specific sensor, unless a hydraulic propeller governor is used. However, during installation and occasionally during use, it should be checked to assess the state of health of the reducer.

| Gearbox oil temperature [°C] | Versions without HG-m |
|---|---|
| *Maximum* | 110 |
| *Minimum in flight* | 20 |
| *Typical* | 90 |

*06-07-C*

| Gearbox oil temperature [°C] | Versions with HG-m |
|---|---|

| | |
|---|---|
| *Maximum* | 130 |
| *Minimum in flight* | 20 |
| *Typical* | 105 |

*06-08-C*

The temperature of the reduction gear oil represents an index of the efficiency of the transmission gears. In case of overtemperature it is necessary to overhaul the reducer.

### *06-01-07 Coolant temperature*

The coolant temperature is detected by a sensor for each cylinder bank.

| **Coolant temperature [°C]** | **All versions** |
|---|---|
| *Maximum* | 102 |
| *Minimum in flight* | 72 |
| *Typical* | 90 |
| *Maximum difference between banks* | 5 |

*06-09-C*

It is necessary to keep the coolant temperature under observation during the flight, to detect any anomalies that could compromise safety.

### *06-01-08 Inlet Air Temperature (IAT)*

The temperature of the supply air is detected in the airbox by the specific sensor set up for the injection system. This temperature can be read using an EFIS system with CAN interface.

| **Supply air temperature [°C]** | **All versions** |
|---|---|
| *Maximum* | 75 |
| *Minimum in flight* | -20 |
| *Typical* | 40 |

*06-10-C*

**A fuel temperature above the value shown indicates mechanical or electronic problems, and can cause detonation and serious damage to the power unit. Do not fly until the problem is identified and corrected.**

Below 15°C, with particular environmental conditions, impact ice can form on the throttle valve.

Above 55°C, in particular conditions, vapor lock may occur in the fuel circuit.

At temperatures below 0 °C, starting may be difficult with the battery not in a perfect state of charge. If necessary, use a second battery connected in parallel to the one installed on the aircraft and in a perfect state of charge for cold starting.

The minimum temperature indicated is intended for starting with a cold engine.

### *06-01-09 Contingency*

The contingency operating limits of the engine are due to the need to allow an adequate lubricating action on the mechanical parts. The fuel injection system, on the other hand, is substantially insensitive to contingency conditions.

| **Acceleration [g]** | **All versions** |
|---|---|
| *Along the longitudinal axis X* | ± 10 |
| *Along the transversal axis Y* | ± 10 |
| *Along the vertical Z axis* | +10/-0.5 (max 5 seconds) |

*06-11-C*

### *06-01-10 Tilt angles*

Similarly to what has been described for contingency loads, the limits on the angles of inclination of the engine with respect to the horizontal position are due to the need to allow an adequate lubricating action on the mechanical parts.

| Angle [deg] | All versions | |
|---|---|---|
| | Minimum oil level | Maximum oil level |
| *Around the pitch axis* | +55/-10 | +55/-18 |
| *About the roll axis* | +36/-47 | +49/-53 |
| *Around the yaw axis* | ± 90 | ± 90 |

*06-12-C*

The angles refer to the condition of minimum oil level and maximum oil level. On the pitch axis a positive angle brings the propeller flange up; A positive angle on the roll axis causes bank #1 to rotate downward. These angles are to be interpreted as bank angles with respect to the flight direction: if the angle is accompanied by the centrifugal action implicit in coordinated maneuvers, the bank angles can be even greater.

### *06-01-11 Electric voltage*

The injection system is able to function correctly, compensating for any variations in the voltage of the recharging system within the indicated limits.

| Electric voltage [volt] | All versions |
|---|---|
| *Maximum* | 15 |
| *Minimum to start* | 11.8 |
| *Minimum for flight* | 11.7 |
| *Typical* | 12.5-13.5 |

*06-13-C*

The minimum operating voltage of the engine is higher than 8.5Volt; the minimum voltage for the flight shown in the table must be understood as the minimum voltage supplied by the recharging system with the engine at full flight speed.

The voltage read on the instrument (voltmeter) is the average between the recharge voltage and the battery voltage: for this reason, with low battery voltage values, the instrument will read values even lower than the typical voltage indicated. This condition therefore does not indicate a fault in the recharging system.

Before carrying out any maintenance work on the aircraft or engine, electrically isolate the injection control units from the system.

## 06-02 Operating fluids

### *06-02-01 Cooling liquid*

Use only **ethylene** glycol based coolants: these liquids must be mixed with water. Protection from freezing is guaranteed down to –40°C, in case of 50% dilution: for different dilutions, refer to the installation manual.

The use of **propylene** glycol-based coolants is not permitted: their eventual use voids any warranty condition on the engine or on its parts.

### *06-02-02 Engine oil*

Use only fully synthetic or mixed based lubricants intended for use in gasoline engines. SAE 10W/40 multigrade oil covers a very wide range of ambient temperatures and is therefore to be considered the preferential choice for temperate climates such as Europe. Use only lubricants with API SG specification or higher.

The choice of the optimal viscosity of the oil to be used must be made on the basis of the average atmospheric temperature of the area of use. If the engine is used in particularly hot climates, it is advisable to increase the frequency of oil changes.

The maximum permitted lubricant consumption is 0.5 liters every 10 hours of operation at full speed.

If the lubricant consumption exceeds that specified, the engine must be overhauled.

After the first 10 hours of operation, it is necessary to replace the engine oil and oil filter: failure to replace this may result in loss of performance and damage to the engine.

In case of prolonged inactivity of the engine, it is advisable to replace the oil before the period of inactivity.

### *06-02-03 Gear oil*

Use specific lubricants for use with 80W-90 thermal grade hypoid gears.

The maximum permitted oil consumption for the gearbox is 0.1 liters every 10 hours.

A reduction gear lubricant consumption higher than specified is probably due to overheating of the transmission gears or oil seal leakage during operation. In this case it is therefore necessary to overhaul the reducer.

After the first 10 hours of operation, it is necessary to replace the reduction gear oil: if it is not replaced, damage may occur to the reduction gears or to the propeller pitch adjustment system, if installed.

### *06-02-04 Fuel*

The following types of fuel can be used

- Unleaded petrol RON 91 or higher
- Red petrol 91 octane or higher

It is possible that there are water residues or small intrusions in the fuel: for this reason it is good practice to filter the fuel before placing it in the tanks, in order to preserve the fuel circuit from impurities that could damage its components.

**The use of AVGAS petrol was not verified during testing: do not use this type of fuel for any reason, as it could seriously damage the injectors and the engine, even causing it to shut down.**

**Replace the fuel filter at the intervals set out in the ordinary maintenance schedule: failure to replace it can cause performance degradation or sudden engine shutdown.**

Using fuel with anti-knock characteristics lower than the prescribed ones can cause damage to the mechanical components of the engine. In case of accidental use of these fuels, a check must be carried out at an authorized service center.

If the engine is stopped for a long time, it is necessary to check the correct functioning of the injectors and fuel pumps: in fact, they could be blocked by fuel residues, making starting difficult or impossible.

The petrol formulation varies between summer and winter: it is therefore important to make sure you use fuels prepared for the climatic conditions in which the engine operates.

Avoid storing fuel for months and use winter fuel in the summer. Summer fuel has a lower aptitude for evaporation as the more volatile components are eliminated: this decreases the risk of vapor lock in the fuel system.

## 06-03 General criteria of use

To preserve the integrity and efficiency of your engine it is necessary to carefully follow the instructions contained in the operating manual and in the maintenance manual.

### *06-03-01 Checks before starting*

**Risk of burns: always perform the pre-flight checks with a cold engine.**

**Always make sure, before proceeding with the checks, that the control unit on and off switch is in the off position.**

**Make sure the master switch is in the off position.**

**In the event of anomalies found during the pre-flight checks, do not use the engine before having removed them.**

**a.** Overall control

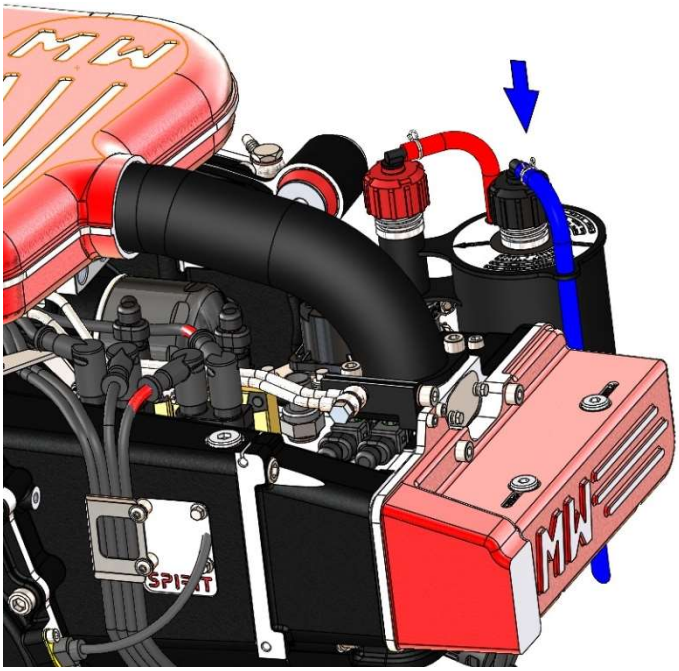
Remove the engine cowling and check that there is no slackness in the fasteners, especially the radiator, fuel pipes and cooling system pipes.
Check the state of wear of all the plastic fittings and the engine suspension pads.
Check for cracks or looseness in the engine mount.
Check the tightening of the propeller and the absence of any play between the blades and the propeller hub.

**b.** Leak check

Check for fuel, coolant or lubricant leaks. In particular, before moving the aircraft, it is advisable to check whether there are stains or sludge on the floor below the engine or the tanks which can be traced back to defects in the on-board systems. Also consider the fact that, due to the presence of the propeller, a possible loss of liquids in flight can cause stains or halos even very far from the point where it occurs.

**c.** Coolant level

Check the coolant level in the expansion tank. The check must be carried out by unscrewing the cap of the expansion tank (black cap) and checking visually or with a graduated dipstick the level reached by the coolant. The expansion vessel must be filled to at least two-thirds of its height (about 0.48 liters). The total capacity of the expansion vessel is 0.70 liters.




*06-01-P*

If necessary, top up with coolant of the same quality as that in the engine .

Any excess coolant is expelled from the system through the pipe provided on the cap of the expansion tank, once the engine has reached operating temperature.

Make sure that you have screwed the cap up to the seal (you will feel some friction when screwing it). If the level of the liquid contained in the expansion tank is zero or very low, it is also necessary to unscrew the cap of the pressurized circuit (red cap).

**Unscrew the cap of the pressurized circuit only when the engine is stopped and cold: otherwise serious burns and personal injuries may result.**

If the liquid level inside the pressurized circuit top-up duct is at the verge, simply screw the cap back on and top up the level in the expansion vessel; if the level in the pressurized circuit top-up duct is low, it is necessary to bleed the cooling system, not before having identified and removed the cause that led to the loss of level.

If the engine requires frequent top-ups to the water circuit, there is likely to be a leak in the cooling circuit or from the head gasket: running the engine in these conditions can cause detonation phenomena, with consequent serious mechanical damage.

## d. Engine oil level

Check the lubricant level in the engine and top up if necessary. The oil level must be between the two notches on the dipstick: the quantity between the two notches is approximately 0.55 liters.

Avoid introducing into the engine a quantity of oil higher than the maximum permitted, which would be expelled by the propeller.

To tighten and remove the filler cap it is possible to use the tool cod. X283.

## e. Gear Reduction

Check the state of wear of the gears and of the lubricant: this check must be performed by unscrewing the cap located on the top of the gearbox and visually assessing the state of the contact surfaces on the driven gear (propeller gear), which must be free from cracks, pitting or yellowing and have a uniform and shiny appearance.

To tighten and remove the filler cap it is possible to use the tool cod. X283.

Apply a light load by hand to the end of a blade, first in one direction, then in the opposite one, without turning the engine shaft: in this way it is possible to evaluate the play between the gears of the reducer. When the engine is cold, the movement of the tip of the blade must be approximately 1 and a half millimeters, and in any case not to exceed three millimeters.

Rotate the propeller by hand in the direction of normal engine operation, completing at least one revolution: no roughening or suspicious noises should be heard. If so, check the reduction gear before starting the flight. The compression of the cylinders with the engine stopped is very low due to the presence of the decompressors.

In the event of considerable play, roughness or variations in the smoothness of the rotation of the propeller, contact an authorized center for the necessary checks.

Avoid rotating the propeller in the opposite direction, as this could damage the automatic timing chain tensioning system or the starting system.

## f. Fuel system

From the cockpit, activate the auxiliary pump for about 5 seconds: check from the instrumentation that the system is under pressure, i.e. that it reads at least 3 bar, and also the electrical absorption of each pump. After having turned off the pump and having returned the master switch to the off position, follow the fuel line, from the tanks to the engine, and check for the absence of leaks or even small seepages

of fuel. Carefully check the area of the fuel shunt, which must be clean and free from sludge or greenish halos.
If the FD-m fuel pump and filter unit is installed, open the container and check for leaks from the components and fuel lines; also check that the pump sealing bands are tightened.

**In case of leaks or even in doubt, do not start the engine and contact a service centre.**

**A greater than normal electric absorption of the fuel pump indicates an anomaly in the system or damage to the pump itself: do not fly in such conditions.**

**g.** Throttle control

Fully depress the accelerator control located in the cabin and bring it back to the minimum position: pay attention to any sticking or roughening of the control.

**h.** *Exhaust system*

Carefully observe the exhaust manifolds and the silencer and check for the absence of cracks, lubricant or fuel leaks, or exhaust gas vents, especially in the area of connection to the engine. Also check the condition of the springs and retaining screws.

**A damaged exhaust system causes a decrease in engine performance and can cause poisoning, burns or fires.**

**i.** *Electrical system*

Inspect all the electrical connectors and especially the condition of the cables leaving the connectors; check the tightening of the mass cables and of the power positive; check the spark plug wires and the fit of the cap on the spark plug; check that all the fixing points of the wiring to the engine are correctly tightened.
Check the efficiency of the anti-vibration fixing elements of the control unit and of the tightening screws of the unit itself; check the efficiency of all the fuses: if a fuse blows, the relative red check light will be on.
If dual battery systems are used, before turning on the engine, check the efficiency of both batteries by setting the master switch first to position A and then to position B: the voltage read in both cases must be greater than 11.7 volts; otherwise it is necessary to recharge the flat battery before starting the engine.

## *06-03-02 Startup*

**Do not leave the aircraft unattended with the engine running. Before starting the engine, make sure that no one is near the aircraft or in an area considered dangerous.**

Thanks to the injection system, no manual enrichment of the mixture is necessary for starting, both with a hot and cold engine, as the enrichment is managed in automatic mode.

The startup sequence is as follows.

**a.** Bring the throttle control to the minimum position.

For safety reasons, the injection system prevents starting the engine with the throttle open more than 10%.

**b.** Turn the master switch to the on position: on ignition, the main fuel pump is operated for approximately 2.5 seconds to pressurize the fuel system; the pump will restart automatically when the engine is switched on, and will switch off automatically when it is switched off.

**c.** Turn both injection switches to the on position.

**d.** Checking the fuel pressure: if the fuel pressure is greater than 2.7 bar, the starter engine can be operated; if the pressure is lower than this value it is necessary to activate the auxiliary fuel pump in order to pressurize the fuel circuit.

The automation of the fuel pump represents a safety device in the event of breakage of the fuel circuit due to an accident or other cause, with the engine stopped, the pump does not turn and therefore does not put fuel into circulation. Furthermore, the pump is of the non-transparent type, i.e. if it is stopped it does not allow the passage of fuel due to leakage.

**e.** Operate the starter. The start button must be pressed for no more than 10 seconds continuously. If after the third attempt the engine does not start, desist from any other attempt, and carry out the checks in section 08-01 of this manual. It is important to activate the starter device only if the engine is completely stopped: the engagement of the starter release device on the moving crankshaft can cause damage.

The injection system adjusts the idling speed automatically, passing from an idle speed of about 1800-2200 rpm with cold engine (depending on the version and mounted propeller), to a hot speed of 950-1200 rpm.

**f.** About 5 seconds after starting, check the oil pressure, which must be within the envisaged limits.

Avoid switching off the engine immediately after starting, especially before the oil temperature has reached at least 40°C. If it is necessary to switch off the engine with the oil temperature still below 40°C, wait at least 5 minutes before trying to switch it on again: this is necessary to allow the oil contained in the automatic decompression device for starting to flow out.

### *06-03-03 Heating*

The engine warm-up procedure is performed fully automatically by the FADEC system as described below.

**a.** When starting, with the oil temperature below 50°C, the engine automatically revs up to around 1300 rpm and, after a few seconds, between 1800 and 2200 rpm. Upon reaching 50°C, the FADEC system will impose the new idling speed on the engine, between 950 and 1200 RPM.

**b.** In the case of coolant temperatures above 50°C, the engine will run at a speed between 950 and 1200 RPM from the first instant after starting.

**c.** To consider the warm-up phase finished, it is necessary to check that the coolant temperature of both cylinder banks is above 72°C: if this condition is not verified, it is necessary to keep the engine at around 2000 RPM to accelerate its warm-up.

Never exceed the 3000 RPM regime with water temperature lower than 72°C and oil temperature lower than 50°C: this eventuality, which can seriously damage the mechanics, is recorded in the memory of the control unit and causes the revocation of the warranty on the engine and its components.

The EM-m instrument facilitates the management of the heating phase by providing an indication of the heating condition.

### *06-03-04 Before takeoff*

After the warm-up period, with the engine warm and before take-off, it is necessary to carry out some checks and operational tests on the engine, as described below.

**a.** Check that the fuel pressure at idle is higher than 3 bar.

**b.** Check that the oil pressure at idle is above 0.8 bar.

**c.** Bring the engine to 2700 rpm and carry out the checks listed below.

**d.** <u>Check injection systems redundancy</u>
Alternately switch off each of the two injection systems: after a short period, necessary for re-phasing the control units, there must be no significant variation, either in the speed or in the regularity of operation.

**e.** <u>Check the charging circuit</u>

Turn off the master switch. The engine must remain running without any hesitation; at the same time, a voltage variation must be read on the voltmeter, the extent of which depends on the state of charge of the battery: usually there is a voltage increase between 0.5 and 1 volt.
In the case of systems with double coils, it is necessary to check the efficiency of both coils.

**f.** Check auxiliary pump

Operate the auxiliary pump: at constant speed, an increase in fuel pressure of approximately 0.4 bar should be read; there should be no significant difference in rpm. The battery recharge voltage must not undergo significant decreases, and in any case must remain above 12V.

**g.** Throttle command response

Bring the throttle control to full opening: the engine must reach the foreseen revolutions.
Bring the throttle back to minimum: the engine must not stall or show irregularities.
Also check that the throttle control runs smoothly and without jamming.

**If even one of these checks is not passed or if there are doubts, it is necessary to abandon the flight and carry out all the necessary checks on the ground.**

### *06-03-05 Take off*

**a.** Make sure that you have activated the auxiliary fuel pump and that you have inserted both injection control units.

**b.** Bring the throttle control to full open and lift off the ground.

**c.** Keep the throttle fully open for the time necessary to gain altitude as quickly as possible and in any case for no more than five minutes.

**d.** Move the throttle control to the cruising position.

**e.** Switch off the auxiliary fuel pump while checking the pressure in the system at the same time: if the pressure drops after it has been switched off, immediately switch the auxiliary pump back on and land as soon as possible to remove the anomaly.

Avoid keeping the auxiliary pump on for prolonged periods and beyond the critical phases of flight (take-off and landing): prolonged use of the auxiliary pump causes a gradual discharge of the battery.

During the ascent, constantly monitor the values of the engine parameters (water temp., oil temp., oil press., and fuel press.), checking that they are within the foreseen limits.

To avoid overloading the transmission system, do not act suddenly on the throttle control, whether you want to increase or decrease the revs.

**Absolutely avoid taking off with the engine not warmed up, as you can seriously damage the engine causing it to shut down in flight and causing a dangerous situation.**

### *06-03-06 Cruise*

**a.** Set the throttle control in order to obtain the desired cruising attitude, respecting the operating limits.

**b.** If using a propeller with variable pitch control in flight, avoid flying at high loads and low rpm, because this stresses the transmission and accentuates the deterioration of the mechanics; it also has no positive effect on fuel consumption. It is advisable to set a propeller pitch that allows you to fly with MAP values between 23inHg and 27.5inHg and in any case within the maximum continuous power range.

**c.** Constantly check the engine parameters during the flight, to identify any malfunctions before they cause mechanical damage. In particular, avoid flying with coolant or lubricant temperatures below the lower limit value: if this occurs, the cooling radiating surfaces must be reduced.

### *06-03-07 Landing*

**a.** If present, turn on the auxiliary fuel pump.

Avoid keeping the auxiliary pump on for prolonged periods and beyond the critical phases of flight (take-off and landing): prolonged use of the auxiliary pump causes a gradual discharge of the battery.

**b.** Gradually reduce the rpm's by acting on the throttle control.

Thanks to the adoption of liquid cooling, the engine does not undergo sudden drops in the temperature of the operating fluids, even during prolonged descents with the engine idling.

**c.** In the case of a variable pitch propeller in flight, set the propeller to minimum pitch, simultaneously reducing the rotation speed by acting on the throttle control.

**d.** Always modulate the throttle gradually, without subjecting the engine to abrupt variations in speed.

### *06-03-08 Shutdown*

**a.** After landing, keep the engine at low speed for at least 1 minute, in order to make the temperatures of all components uniform and avoid thermal shocks.

**b.** In the meantime, turn off all utilities, including any auxiliary fuel pump.

**c.** Stop the engine first by acting on the secondary injection control switch (circuit B) and then on the primary injection switch (circuit A).

**d.** After the engine has stopped, turn off the main switch (master).

### *06-03-09 Use in winter weather*

In case of use in the winter season or in areas with a particularly cold climate, it is necessary to follow the instructions below.

**a.** Cooling liquid

Increase the proportion of the antifreeze-water mixture, in accordance with the installation manual and the manufacturer's instructions.

**b.** Lubricant

Check that the thermal degree of the lubricant used in the gearbox and in the engine complies with the ambient temperature.

**c.** Cold start

Throttle control closed.
Make sure the battery is fully charged to crank the engine at least 150-180 RPM. Otherwise recharge it before attempting to start it. If the battery installed is not sufficient to guarantee an adequate number of revolutions, use a second battery, connected in parallel to the first.
Use the electric starter for short periods (max 10 seconds at a time). Between one attempt and another, turn the injection system switch off and on again: this produces a further enrichment in the carburetion.

**d.** If the engine does not start

- Open the throttle slightly (in any case less than 10%).
- Replace the spark plugs.
- Reduce the spark plug gap to 0.5 mm to facilitate spark striking.
- Use a less viscous oil.
- Run the engine for about 20 seconds without the spark plugs.
- Preheat the engine with jets of hot air directed at the oil sump and cylinder heads.

A

It is advisable to use only fuel purchased in the season in which the engine is used: in fact, the formulation of the fuel varies according to the climatic conditions, due to the more or less marked presence of some components or additives, in particular alcohols which, due to nature, contain a part of water which in particular conditions can lead to condensation.

If the engine does not start, it is likely that there is condensation or ice forming in the intake system, due to the high relative humidity of the air. In this case it is advisable to blow or replace the spark plugs. In addition to this eventuality, there is the possibility of the presence of condensation water also in the fuel: to avoid problems due to the presence of water in the fuel, the fuel circuit must be equipped with a decanter filter, to be placed at the lowest point of the circuit itself and before the fuel pumps, in order to collect any water present in the tanks by gravity.

It should be noted that under certain conditions, the presence of small drops of water on the spark plug electrodes can cause irreversible damage.

An advantage of the injection system is the absence of the Venturi tube, present instead in the carburetor which, by subjecting the air to expansion, facilitates the formation of ice inside the intake ducts.

In extreme cases, even in injection systems, freezing can occur in the intake duct, due to the cooling of the drops of condensate impacting the surface of the throttle valve: this phenomenon is very rare, and only occurs at low throttle angles, when the presence of the butterfly valve in the duct constitutes an obstacle for more than 2/3 of the total section, and with cold engine.

## 06-04 Behavior in an emergency

**In the event of operating conditions exceeding the prescribed limits, before using the engine again it is necessary to contact an authorized assistance center.**

Exceeding the operating limits is recorded in the injection control units, and results in the revocation of the product warranty conditions.

Any exceeding of the limit operating conditions must be noted in the engine logbook, detailing the value reached and the permanence time outside the limit parameters, and reported in the event of maintenance or sale of the engine.

**In the event of an emergency landing, with the engine off or with irregular operation, it is necessary to maintain a correct attitude and an adequate speed to avoid stalling the aircraft.**

For further checks, consult the maintenance manual.

### *06-04-01 Accidental stop - Start during flight*

**a.** Shut off all electrical consumers not needed for the flight.

**b.** Check and if necessary restore the status of the fuse placed to protect the injection system.

**c.** Check on the EM-m instrument or by means of the injection failure warning lights located on the aircraft cockpit, which control unit is faulty and exclude it from the system by inserting the corresponding kill switch.

**d.** Energize the auxiliary fuel pump.

The preventive activation of the auxiliary pump serves to exclude a possible cause of shutdown, without wasting time in identifying it.

**e.** Set the throttle lever to the idle position.

**f.** Operate the starter; in case of unsuccessful starting, repeat the operation selecting the alternative control unit.

**g.** Even if the engine starts, land as soon as possible to identify and remove the cause of the failure.

### *06-04-02 Overspeed*

The engine is equipped with an electronic system which implements a controlled decrease in power above the maximum permitted revs: this decrease is obtained by decreasing the value of the ignition advance and by cyclic misfiring on the cylinders.

However, the intervention of the electronic limiter must be avoided as much as possible, since it introduces additional impulsive loads in the transmission system and in the crankshaft compared to those of normal operation.

A

Flying above the maximum permitted revs and therefore with prolonged intervention of the electronic rev limiter produces potential damage to the engine, which is difficult to diagnose. In the event of prolonged use (longer than five seconds) in the limiter intervention regime, the engine must be subjected to a complete overhaul.

### *06-04-03 Exceeding the maximum cooling temperature*

**a.** Reduce power to the minimum necessary for flight as soon as possible and in accordance with the flight condition.

**b.** In the case of installations with a variable pitch propeller, favour low rotation speeds with a high MAP value.

**c.** Increase flight altitude if possible.

**d.** Avoid setting engine speed values lower than 3000RPM.

**e.** Land as soon as possible.

### *06-04-04 Exceeding the maximum lubricant temperature*

**a.** Reduce power to the minimum necessary for flight as soon as possible and in accordance with the flight condition.

**b.** In the case of installations with a variable pitch propeller, favour low rotation speeds with a high MAP value.

**c.** Land as soon as possible.

### *06-04-05 Oil pressure below the in-flight limit*

**c.** Reduce power to the minimum necessary for flight as soon as possible and in accordance with the flight condition.

**d.** In the case of installations with a variable pitch propeller, favour high rotation speeds with a low MAP value.

**e.** Land as soon as possible.

### *06-04-06 Low oil pressure on the ground*

**a.** Stop the engine.

**b.** Check the quantity of lubricant in the sump and, if necessary, top up.

**c.** Check for any leaks in the lubrication circuit: in particular, check the oil filter area and the upper part of the engine, where any leaked lubricant can easily accumulate.

**d.** Check for leaks from the radiator or its fittings.

**Do not fly until the cause of the pressure loss has been identified and removed.**

### *06-04-07 Fuel pressure below flight limit*

**a.** Open any reserve fuel tanks and activate the booster pump as soon as possible.

- *If the pressure rises*

  **b.** Take the aircraft to the first available field and land.

- *If the pressure does not increase*

  **b.** Turn off the booster pump and decrease the power output compatibly with maintaining safe flight conditions.

  **c.** Prepare for the possibility of engine shutdown due to lack of fuel by identifying areas for an emergency landing.

### *06-04-08 Low fuel pressure on the ground*

Stop the engine, wait for the engine to cool down and carry out some checks, as summarized below.

- Activate the auxiliary pump: if the pressure is restored, it means that the main pump is faulty; do not fly until the master pump is replaced.
- Refill the tanks with fuel.
- Look for fuel leaks under the aircraft or near the pressure regulator. If a fuel leak is identified, close the valves and proceed to eliminate the leak.

**Gasoline and its vapors are highly flammable. Avoid working indoors, near sources of heat or open flames. Avoid using electrical or electronic equipment near fuel spills.**

Do not run the engine until the leak has been removed.

- Replace the fuel filter.
- Carry out any further checks, in accordance with the instructions in the workshop manual.

### *06-04-09 Battery voltage too high*

**a.** Check the position of the main switch (master) and if necessary reset it to the on position.

**b.** If the voltage does not decrease, reduce the engine revs compatibly with the flight conditions to avoid any damage to the electronic components.

**c.** Land as soon as possible.

A After flying with the master disconnected, the voltage regulator must be replaced, even if it appears to be working.

### *06-04-10 Battery voltage too low*

Check for the presence of the alarm or the switching on of the generator charge light.

- *In case of positive verification*

  **a.** There is probably a voltage regulator failure: turn off all utilities that are not essential for the flight.

  **b.** Turn off the auxiliary fuel pump, in order to reduce the electrical consumption as much as possible.

  **c.** Set the engine speed to about 3500 rpm and, if using a variable pitch propeller, increase the flight speed in order to cover the maximum distance.

  **d.** Land as soon as possible, with the warning of reducing the revs only when approaching landing, to avoid unwanted engine shutdowns.

A Once the above indications have been implemented, a 16Ah battery in a perfect state of charge allows the engine to be kept running for at least 50 minutes from the moment the generator is disconnected.

A In these conditions, reducing the rotation speed could cause the engine to stop undesirably.

A After operation without charging the generator, the entire charging system must be checked and replaced if necessary.

- *In case of negative verification*

  **a.** Probable battery failure: therefore, exclude all utilities not essential for the flight.

  **b.** Exclude the battery from the recharging circuit by acting on the main switch (master).

  **c.** Close to landing, exclude the main control unit (circuit A): in this way the engine automatically remains above 1500rpm.

  **d.** Land as soon as possible paying attention to engine revs.

A After flying with the master disconnected, the voltage regulator must be replaced, even if it appears to be working.

## *06-04-11 Injection alarm*

The EM-m instrument is designed to communicate with both control units via the CAN line and is designed to signal anomaly in the electrical system (such as, for example, a broken sensor), or operating anomalies of the control units, or exceeding the engine operating limits. The switching on of the red status light identifies a dangerous condition for which it is advisable to land as soon as possible or not to take flight.

If during the flight the red status light turns on, it is advisable to land as soon as possible, if the status light is red when the instrument is switched on, it is forbidden to fly.

The use of the engine with the red status light will be recorded in the instrument. Using the engine with the status light red voids the engine warranty.

- The EM-m instrument is programmed to signal operating anomalies to the pilot with a series of alarms, for a complete description and understanding of the alarms and their meaning, refer to the instrument manual.
- If the EM-m instrument is not present, after one of the two injection warning lights comes on, reduce the engine rpm and land as soon as possible.

## *06-04-12 Generator alarm*

**a.** Check the condition of the 30 A fuse installed to protect the recharging system and restore it if necessary.

**b.** Check for overloads in the electrical system and, if necessary, disconnect unnecessary or faulty utilities.

**c.** Turn off the auxiliary fuel pump, in order to reduce the electrical consumption as much as possible.

**d.** Set the engine speed to about 3500 rpm and, if using a variable pitch propeller, increase the flight speed in order to cover the maximum distance.

**e.** Land as soon as possible, with the warning of reducing the revs only when approaching landing, to avoid unwanted engine shutdowns.

Once the above indications have been implemented, a 16Ah battery in a perfect state of charge allows the engine to be kept running for at least 50 minutes after the generator has been disconnected.

In these conditions, reducing the rotation speed could cause the engine to stop undesirably.

After operation without charging the generator, the entire charging system must be checked and replaced if necessary.

## *06-04-13 Abnormal vibrations*

- If the vibrations are very high and could cause structural damage to the aircraft, immediately stop the engine and prepare for an emergency landing.
- If the vibrations are compatible with maintaining the structural integrity of the aircraft.
  - **a.** Check the EM-m instrument or the control unit warning lights present on the cockpit for any errors on the injection control units, and act accordingly by switching off any faulty component. If the fault persists, reactivate the main injection control unit and exclude the secondary control unit.
  - **b.** Gradually reduce the engine speed to find a speed where the vibrations are less.
  - **c.** If not, increase the rpm and look for a new rpm where the vibrations are lower.
  - **d.** Land as soon as possible.

## *06-04-14 Erratic operation*

- Turn on the auxiliary fuel pump.
- Check that the fuel valve is not partially closed.
- Check the operating status of the injection control units on the EM-m instrument or in the cockpit and possibly exclude the faulty control unit.
- Vary the engine rotation speed, first increasing it, then decreasing it, to try to improve the regularity of operation.
- Land as soon as possible.

# 07 ENGINE CHECKS

All checks must be carried out according to the methods described in the latest revision of the maintenance manual.

A Only qualified technicians educated on the particular type of engine are authorized to carry out maintenance and repair work.

Also take into account the directives contained in the service bulletins according to their priority with respect to what is described in the manuals.

## 07-01 Tool kit list for pre-flight or emergency checks

It is advisable to create a small set of tools to be used for pre-flight checks and possibly to be taken in flight, to carry out small jobs in the event of anomalies encountered during travel.

- Scissors
- Needle nose pliers
- Phillips screwdriver
- Allen Key 5 mm
- Allen Key 6 mm
- Allen Key 8 mm
- Fixed wrench 8 mm
- Fixed wrench 10 mm
- Fixed wrench 13 mm
- Fixed wrench 17 mm
- Fixed wrench 19 mm
- Oil filler cap tightening lever cod. X283

## 07-02 Preservation and recovery of service after prolonged inactivity

Refer to the ordinary maintenance manual.

## 07-03 Engine protection for use in harsh climates

a. Check the most correct viscosity grade for engine oil and gear oil.

b. Modify the mixing of the antifreeze liquid with the water, in order to guarantee the correct protection against freezing. Check the table in the installation manual and the antifreeze manufacturer's instructions.

c. Use fuel specifically formulated for operating in harsh climates.

d. Always keep the battery in excellent working order.

e. In case of temperatures below -15°C, warm up the engine adequately before starting the ignition.

f. Before turning off the engine after use, wait a few minutes to make the temperatures uniform.

# 08 TROUBLESHOOTING

Only qualified technicians educated on the particular type of engine are authorized to carry out maintenance and repair work.

If the following collection of remedies does not solve the problem, you should contact an authorized service center.

## 08-01 Operating anomalies and their resolution

**The engine must not be used until any possible problems have been identified and corrected.**

### The engine starts hard in cold weather

- Check, and if necessary restore, the correct battery charge level: at least 12.2Volt.
- Slightly open the throttle control (however less than 10%).
- Reduce the gap of the spark plugs to 0.5 mm (regardless of the type of spark plug used).
- Replace the spark plugs.
- Check that all control unit sensors are connected and working.
- Warm up the engine before starting in case of atmospheric temperature below -15°C (5°F).

### Engine does not start

- Make sure the main switch is in the on position.
- Make sure the injection system switch is in the on position.
- Check, and if necessary restore, the correct battery charge level: at least 12.2Volt.
- Make sure that the fuel pressure is at least 2.7 bar: otherwise activate the auxiliary fuel pump.
- Make sure that the auxiliary control unit is also switched on.
- Check for the presence of fuel in the tanks.
- Replace the fuel filters.
- Replace the spark plugs.
- Make sure the throttle potentiometer is connected to the system.

### Coolant temperature too low

- Excessive radiator size. Partialize the radiating surface with adhesive tape or flabella.
- Faulty thermostat: in this case the engine also struggles to reach operating temperature. Eventually replace it.

### Engine oil temperature too low

- Reduce the amount of oil in the sump.

- Increase the operating temperature of the engine, choking the water radiator and reducing the ventilation air intakes on the engine hood.
- If present, reduce the size of the radiator or divide the surface exposed to the flow.

Low oil pressure

- Check and, if necessary, top up the correct engine oil level.
- Replace the oil filter.
- Identify possible pressurized lubricant leaks from the head gasket or oil filter.
- Use a higher heat rating lubricant.

Maximum take-off rpm too low

- Reduce the pitch or diameter of the propeller.
- Possible failure of one of the four spark plugs: in this case there is also a marked increase in vibrations; change the four spark plugs.
- Check the engine oil level in the sump and top up if necessary.
- Check the fuel pressure at full throttle opening: if it does not reach at least 3 bar, it is necessary to inspect the fuel distributor and fuel pumps.
- Perform ultrasonic cleaning of the fuel injectors.
- Check the efficiency of the decompression system and the ADC valve.

The coolant in the expansion tank is frequently below level

- Check that the pressurized cap is closed correctly.
- Identify possible leakage from the cooling circuit, in correspondence with the connection sleeves.
- Identify possible leaks from the radiator elements: replace the radiator if necessary.
- Check the efficiency of the pressurization valve in the cap: replace the cap if necessary.

Coolant temperature too high

- Presence of bubbles in the cooling circuit: bleed the system.
- Insufficient coolant level in the expansion tank: restore the level.
- Check for leaks in the cooling circuit which can cause loss of liquid in the system.
- Wrong glycol-water mixture, with excess glycol. Restore the correct percentage in relation to the environmental conditions.

*Engine oil temperature too high*

- Check the quantity of oil in the sump and top up if necessary.
- Possible damage to the propeller: carry out a thorough check of the mechanics.

*Gear oil temperature too high*

- Check the quantity of oil in the gearbox and top up if necessary.

- Possible damage to the reducer: carefully check the state of the gears.

Presence of oil emulsion under the filler cap or in the breather system

- Excessively low operating temperature: reduce the radiator surface.
- Head gasket failure: it is necessary to intervene by overhauling the engine.

Excessive vibrations

- Incorrect propeller tightening: restore it.
- Propeller unbalanced due to the presence of deposits or damage or due to dynamic balancing errors.
- Propeller polar moment of inertia too low.
- Dirty or damaged spark plugs: replace them.
- Alternately exclude the main control unit or the auxiliary one: in the event of a positive response, replace the damaged control unit.
- Throttle position sensor failure: contact a service center.
- Torsional vibration damping system faulty: contact an authorized service center.

## 08-02 Malfunctions in the injection and ignition systems

The injection system has an internal diagnosis capable of detecting input and command errors. The system is also equipped with the Limp Home strategy, which assigns a default value to the inputs where an error is detected (with the exception of the pickup input), allowing the engine to continue running; if the strategy is activated, the subsequent cold start of the engine will take place with considerable difficulty, with irregular operation.

A

If the engine starts with difficulty and has a very irregular cold idle speed, there is probably a problem with the injection system: in this circumstance, avoid flying and contact an authorized service center for the coding and resolution of the problem.

Very often, faults in the injection and ignition systems are caused by problems with the wiring or connectors: it is therefore very advisable to pay the utmost attention to these components, avoiding subjecting them to traction during maintenance operations; another good rule is to check periodically and before each flight the correct positioning of each branch of the harness, fixing it to other elements if there is a danger of unwanted shaking caused by the flow of the propeller or by vibrations.

If the EM-m instrument is mounted, each error is sent on the CAN line and classified by the instrument itself as a major failure (red) or as a minor error (yellow); The complete table of the EM-m instrument alarms is shown in the EM's installation manual.

The following table shows the sensor failures that the engine control units are able to manage by activating specific Limp Home strategies and the default value that is assigned to the failed sensor

| *Type of failure* | *Limp Home strategy* | *Default value* |
|---|---|---|
| Throttle posistion sensor failure | Yes | 0 % |
| Oil temperature sensor failure | Yes | -50 °C |
| Manifold air temperature sensor failure | Yes | -50 °C |
| Coolant temperature sensor failure | Yes | -50 °C |
| Manifold air pressure sensor failure | Yes | 0 bar |

*08-01-C*

**In the event of major failure, it is necessary to land as soon as possible.**
**In the event of minor failure, the flight can continue, but the engine must be inspected as soon as possible, and in any case before the next flight, at an authorized assistance centre.**

For more details, refer to the instruction manual of the instrument.

## 08-03 Communication of operating anomalies

Each anomaly must be identified and resolved before proceeding to a new mission.

In order to improve and solve any recurring defects, the communication of the anomalies found and their resolution is appreciated, or of any other consideration that can improve the safety in the use of the engine and the clarity of the information contained in these manuals.

The communications must be produced by filling in the form reproduced below, which can be downloaded at www.mwfly.it, and sent to the most convenient authorized MWfly assistance center, or directly by e-mail to info@mwfly.it.

| Fault Communication Form | | | |
|---|---|---|---|
| *Date* | | *Serial No* | |
| *Surname* | | *First Name* | |
| *Phone number* | | *E-mail* | |
| *Aircraft manufacturer* | | *Aircraft model* | |
| *Propeller model* | | *No. of blades* | |
| *Application pulling* ☐ | *Application pushing* ☐ | *Total hours* | |
| *Prevalent use* | *School* ☐ | *Missions > 1 hour* ☐ | *Missions < 1 hour* ☐ |
| *Frequency of use* | *Daily* ☐ | *Weekly* ☐ | *Occasional* ☐ |
| *Prevailing Environmental Temperature* | *Less than 10°C* ☐ | *Between 10 and 35°C* ☐ | *Greater than 35°C* ☐ |
| *Description of the anomaly* | | | |
| *How often?* | *Permanent* ☐ | *Frequent* ☐ | *Occasional* ☐ |
| *Note* | | | |

*08-02-C*

# 09 SIGNATURES AND LIST OF REVISIONS TO THE DOCUMENT

| *Filled out and checked on* | *from* | *Signature* |
|---|---|---|
| *05/09/2023* | *Guido FANTINI* | |
| *Approved on* | *From* | *Signature* |
| *05/09/2023* | *Stefano MARELLA* | |

| *Revision* | *Applicability* | *Chapter* | *Page* | *Date modified* |
|---|---|---|---|---|
| 1 | Da #001911 | B.1. Introduction | All | 05/09/2023 |
| 1 | Da #001911 | B.2. Safety | All | 05/09/2023 |
| 1 | Da #001911 | B.3. Engine description | All | 05/09/2023 |
| 1 | Da #001911 | B.4. Technical features | All | 05/09/2023 |
| 1 | Da #001911 | B.5. Description of the systems | All | 05/09/2023 |
| 1 | Da #001911 | B.6. Operating instructions | All | 05/09/2023 |
| 1 | Da #001911 | B.7. Engine checks | All | 05/09/2023 |
| 1 | Da #001911 | B.8. Troubleshooting | All | 05/09/2023 |