



Engine and Maintenance Manual

for the Exodus Aircraft BMW R1200 engine and gearbox

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Introduction

The BMW R1200 fuel injected engine fitted to the DeltaJet 500 StingRay boasts a rare combination of sophisticated engineering unfamiliar in the world of light aircraft aviation, with double overhead camshaft (DOHC) cylinder heads, fuel injection, and counterbalancing shaft, all combined into one power unit. It also features twin spark plugs in each cylinder head, each plug being equipped with its own dedicated electronic ignition coil.

The engine is cooled through a combination of oil and air. The twin horizontal barrels are finned and kept cool by the flow of air over them while oil from the sump is circulated through the DOHC cylinder heads before being returned after passing through a large oil cooler. The oil system also incorporates an internal thermostatic valve which opens at 85°C, speeding up the warm-up process on the ground.

For aircraft use, the 1,170 cc R1200 engine is modified by Takeoff GmbH to become the TBM12.2 series. It is fitted with a reduction gearbox with a ratio of 3.2, the Takeoff GT-3.2, and also incorporates Takeoff's unique TFD centrifugal clutch and rotary vibration absorber. The centrifugal clutch disengages the propeller at low engine rotation speeds and automatically engages as engine speed rises (when taxiing, for example), removing load on the engine for smoother start-up and idling. It also has a useful additional safety benefit for airfield operations in general.

The R1200 is fitted with a 60A alternator and a YTX14H LiFePO4 battery is installed in the DeltaJet 500 StingRay. If the battery needs to be topped-up, use only a charger specially designed for Lithium batteries. Once started, the engine will continue to run without the battery. The engine will also continue to run if the alternator fails but only as long as the battery retains sufficient charge. If the alternator fails, the warning light will glow bright red.

With Takeoff's specially mapped ECU, the engine produces 115 hp at 7,500 rpm, produces its maximum torque at just over 6,000 rpm, and maintains this pulling power across a very wide rev range.

Starting the engine

This procedure is very simple at all temperatures and atmospheric levels:

- Turn the Master switch to ON.
 - All the instruments will activate and go through their initiation sequence.
 - The Oil Pressure LED and Intelligent Battery Monitor will illuminate.
- Turn the Ignition switch to ON.
 - You should hear the fuel pump activate to pressurise the fuel injection system.
- Press and hold the Starter Button until the engine turns and fires.
 - The Oil Pressure LED should extinguish and the Oil Pressure Gauge should show oil circulation.
 - The Intelligent Battery Monitor should show a green steady light to indicate normal charging.
- Open the throttle and gently warm the engine at approx. 1,800-2,000 rpm.
 - Continue until an Oil Temperature of more than 85°C is shown. This will ensure that the Oil Thermostat is open and oil is circulating through the engine and oil cooler.

1. Oil level check, oil change with filter change

Interval: after 10 hours of operation, then every 100 hours or once a year

Checking the oil level

The sight glass is located under the right cylinder. The oil level depends on the oil temperature: the higher the temperature, the higher the oil level in the oil pan.

Check the oil level with the engine cold: just a short engine run will lead to erroneous readings and cause incorrect topping up. If the engine has been run, a correct display of the engine oil level can only be achieved after approx. 5+ minutes of standstill. The oil level should be between min. and max. of the red ring line – the image illustrates a situation where the oil level is too low.

Note: Oil changes should be performed after warming the motor. Do not touch hot parts of the exhaust system.



Draining the oil

The oil drain screw is located under the engine.

- Put an oil pan under the engine.
- Remove the oil drain screw and drain the oil. Please note, the image shows a drain screw fitted with an optional temperature sensor.
- Dispose of waste oil in an environmentally friendly manner.
- Remove the sealing ring from drain screw and replace with a new sealing ring (Al or Cu 16 x 20 or 16 x 22).
- Reinstall the oil drain screw (M16 x 1.5).
- **Torque to 32 Nm.**



Changing the oil filter

- Unscrew the oil filter and dispose of in an environmentally friendly manner. A BMW adaptor may be helpful (BMW No.: 11 4 661).
- Lubricate the sealing ring of the new oil filter with engine oil.
- Install the oil filter.
- **Torque to 11 Nm.**

Please note: the MAN-MW 77 filter can be replaced with the longer MW 712 if space allows.



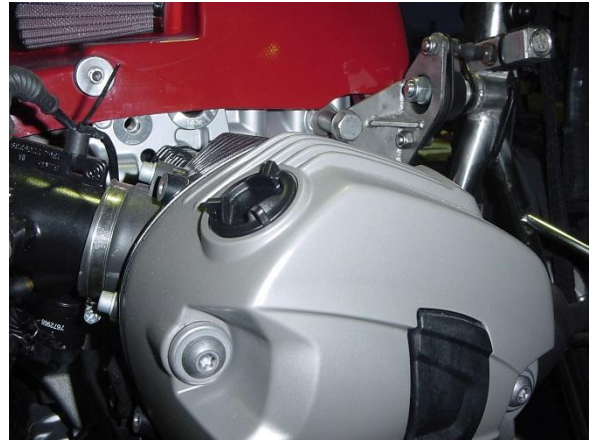
Oil change, Oil filter change

Topping up the oil

- Undo the oil filling screw: a special BMW key may be helpful (No.: 7 691 446).
- Fill the engine with engine oil to approx. $\frac{3}{4}$ in the glass sight window.

A complete oil & filter change will require approx. 4 to 4.5 litres.

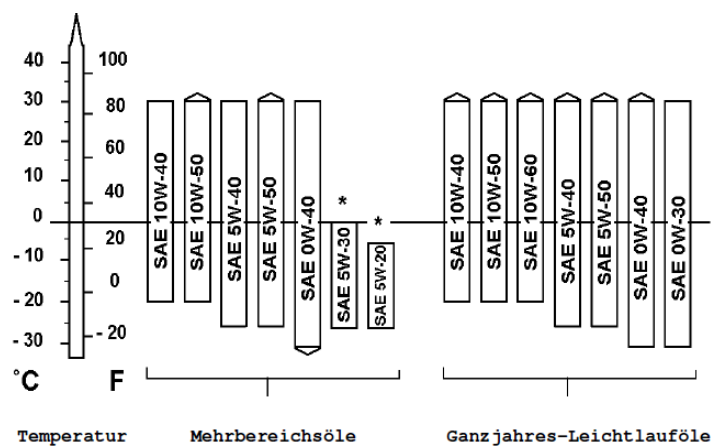
- Tighten the oil filling screw (it can also be done reliably with a screwdriver and wrench). Alternatively, a safety oil filling screw can be purchased from BMW (No.: 7 160 7 696 117).



BMW recommended oils and permissible viscosity classes:

Designation	Operating Temp.	Specification
Castrol Power 1 4T 10W-40 SAE	-20 - 30 °C	API SG / JASO MA
SAE 5W-40	-25 - 30+ °C	API SF / ACEA A2, or better
SAE 5W-50	-25 - 30+ °C	API SF / ACEA A2, or better
SAE 10W-40	-20 - 30 °C	API SF / ACEA A2, or better
SAE 10W-50	-20 - 30+ °C	API SF / ACEA A2, or better
SAE 15W-40	-15 - 30 °C	API SF / ACEA A2, or better

After the first 100h, fully synthetic 5W50 is suitable. However, this must be accompanied with a filter change and a further filter change after 20h.



2. Set Valve Clearance

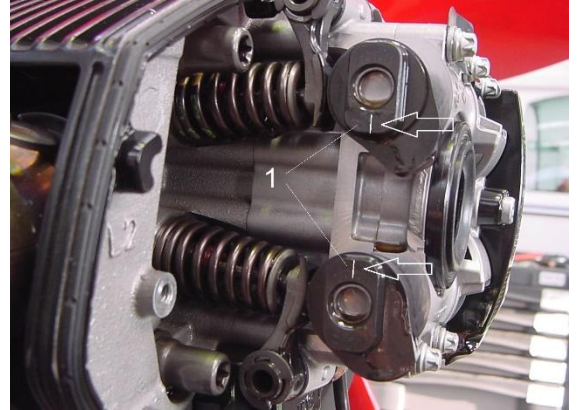
Interval: after 10 hours of operation, then every 200 hours

Remove the black spark plug coil cover and the spark plug coil. Also remove the generator belt cover. Then, remove the two M6 x 72 screws fastening the cylinder head cover and remove the cover.

- Turn the motor over by hand(*) using the generator belt drive until the markings on the camshafts are in line with each other.
- In this position, the inlet and outlet valves are closed and can be checked.

Note: the valves of the other cylinder cannot be adjusted at the same time – the engine must be rotated 360°.

Repeat the steps above on the other cylinder to put into the correct position for adjustment.



Determine the valve clearance between the cam (2) and the drag levers (3) using a feeler gauge (1).

- Do not measure by the recess of the cams.

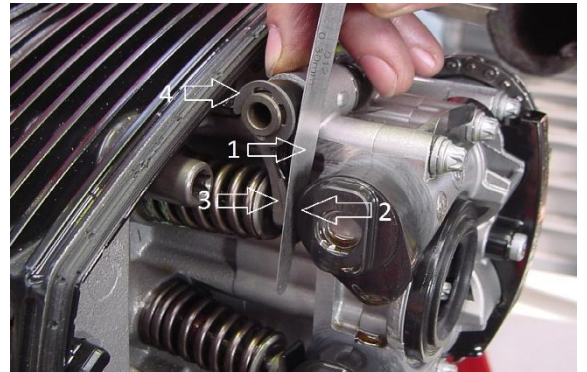
Inlet valve clearance

- with cold motor (<35°C) permissible 0.13 - 0.23 mm

Exhaust valve clearance

- with cold motor (<35°C) permissible 0.3 - 0.4 mm

If the valve clearance is not within the permissible range, the hemispheres must be replaced.



Remember: To check the valve clearance on the other cylinder, the engine must be rotated a further 360°

Setting the valve clearance

- To access the inlet and outlet cam levers, the circlips (4) must be removed.
- Pushing drag lever shafts forward
- Remove the cam lever.
- **Note:** Make sure that the hemispheres do not fall out.
- Remove the hemisphere (1) from the cam lever (2)
- Install a new hemisphere of the correct size (i.e., the old hemisphere value plus the valve play error).
- **Note:** Only hemispheres marked "X" may be used.
- Hemispheres without this marking must be scrapped.



* You may find it difficult to turn the motor over using just the generator belt. We have found that using a 34 mm spanner on the bottom pulley fastening nut make it easier to turn the engine over and line-up the camshaft markings.

Re-installing the cam levers

- Taking care that the hemispheres do not fall out, push the cam lever on to its shaft and ensure it slides on fully. Push back on a retaining circlip.

Note: If the clips are used multiple times, the locking of the cam levers is not guaranteed. Always renew circlips.

- Re-check the valve clearance and ensure it is within the tolerances set out above.
- Replace the cylinder head cover using the M6 x 72 screws.
- **Torque to 10 Nm.**

Important: Check seals are correctly seated on the cylinder head cover before tightening.

3. Replacing the gearbox oil

Interval: Replacement after 10 operating hours, then every 200 hours

Remove the filler screw and copper washer – shown on the right circled in red.

Loosen the two clips on the main exhaust muffler holding the top muffler in place. Also loosen the smaller, lower clip on the 'U' pipe connecting the two mufflers.

This will enable the top muffler assembly to be rotated backwards towards the propeller.

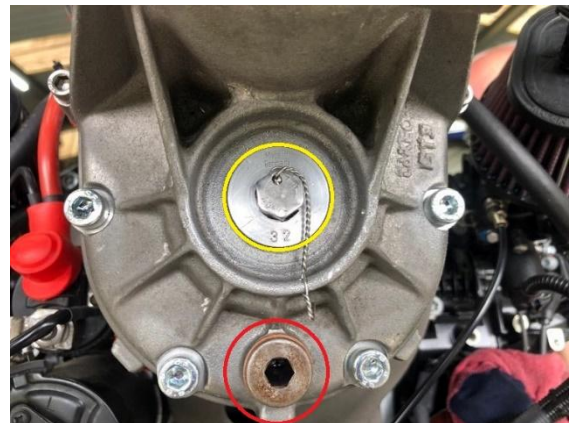
Be careful not to allow the muffler to contact the propeller blades

With a suitable container in place to contain the gearbox oil, remove the oil drain screw and copper washer, and allow to drain completely.

- this is the lower of the screws shown in the picture on the right and circled in red.
- **DO NOT** remove the bolt with locking wire shown here circled in yellow.

Handy Tip: raise the front wheel of the trike approx. 200 mm to help the last of the oil flow out.

Remember to level the trike before refilling!



Refilling

- With the trike level, replace the oil drain screw complete with new copper washer and torque to 28 Nm.
- Carefully add 250 ml of gearbox oil.

Please note: the gearbox oil is high viscosity.

- When 250 ml has been added, replace the filler screw (using a new copper washer) and torque to 20 Nm.

If for any reason the bolt shown in the yellow circle is removed, replace using a new copper washer, torque to 10 Nm, and lockwire in place.

4. Replacing the generator belt

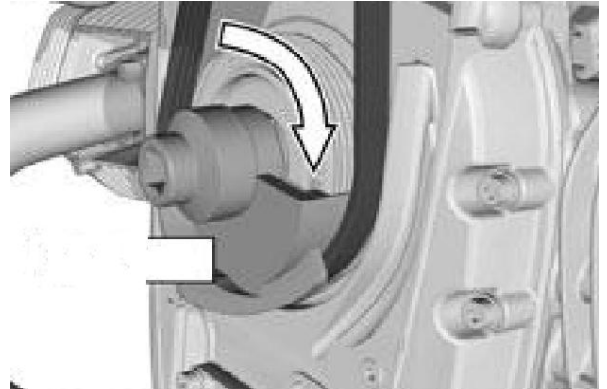
Interval: Replacement after 200 operating hours, check every 100 hours

Warning: Fingers can be trapped between the drive belt and the belt wheel. Install drive belts only with suitable tools.

- Remove the drive belt cover.
- Turn the crankshaft pulley in the direction of the motor rotation (arrow) and gently press the belt forward with a blunt tool.

Installing new belts

- Put the drive belt on the pulley on the generator in a form-fitting manner.
- Put the winding tool (BMW #: 12 3 591) on the belt wheel of the crankshaft and thread the drive belts
- Press the winding tool firmly on the belt wheel.
- Turn the motor on the belt wheel of the crankshaft in the motor rotation direction (white arrow in image) until the drive belt is completely mounted on the pulley.



Note: If the drive belt is not installed in the correct position on the pulleys, the drive belt will be destroyed within a very short time.

Note: If the belt gets too hot, it wears out very quickly and must be provided with a cooling air supply. The drive belt cover is held in place with 5 bolts each of which has a spacer installed between the engine face and the cover.

When refitting the cover, DO NOT REMOVE THESE SPACERS.

5. Replace spark plugs

Interval: Replacement after 400 operating hours

Remove screws (1) and remove cover (2) with washers (3)

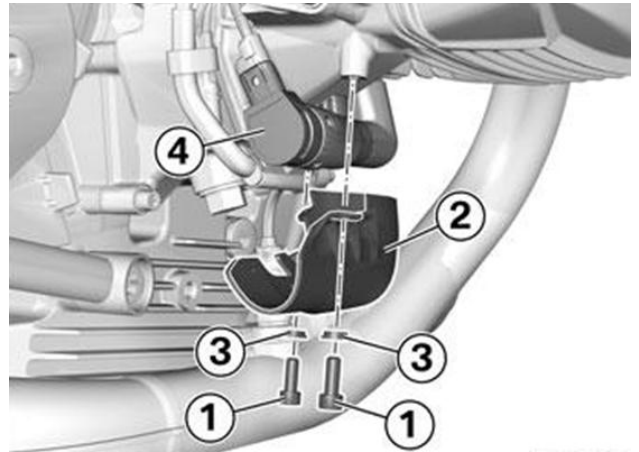
Remove side spark plug coils (4)

Remove main and side spark plugs with a long Spark Plug socket.

Replace with **NGK MAR8B-JDS** M10.

Torque the spark plugs to 18 Nm.

Replace the cover and torque the cover screw to 8 Nm.



6. Air Filters

Interval: Check every 100 hours or less if flying in dusty conditions

The high-performance air filters must be cleaned every 500h (and even more frequently if regularly flying in dusty conditions).

Use a good air filter cleaner and air filter oil (available from the air filter manufacturers and other sources) and follow their instructions.

In general, the procedure is to knock off any external dirt before rinsing with cold water. After air drying, spray or dip the filter into filter cleaning and degreasing liquid. Before re-installing spray or sprinkle the filter with air filter oil.

N.B. Some air filter manufacturers specify that any guarantee or warranty will only be honoured if their branded air filter cleaner has been used.

Chemicals not intended for cleaning and re-oiling air filters made of cotton-type fabric, such as petrol, gear oil, engine oil, light oil, or diesel fuel, must not be used and may render the filter unusable.

Similarly, the use of compressed air to remove visible dust particles may damage the filter matrix and is not recommended.



7. Fuel supply

Interval:

- Change of pump gasoline filters after 100 operating hours (pressure filter if fitted after 400 hours)
 - Change the fuel hoses every 800 hours or every 6 years or immediately if surface cracking or degradation is noted
 - Clean the tank as needed or every 4 years
-

Note: From 2011, E10 petrol fuel has been available in most garages. This type, as well as the super gasoline of 2009, attacks the fuel lines. It is vital to inspect all fuel lines regularly and replace if any surface cracking or degradation is noted. Failure to do so can lead to power degradation and engine failure due to clogged injectors.

The fuel system in the DeltaJet 500 StingRay is relatively simple and designed to prevent vapour bubble formation. From the fuel tank, the fuel passes through a fuel filter and on to the fuel on-off tap. From there it enters the fuel pump, which incorporates a filter within the inlet port to protect the pump, and then to the pressure regulator on top of the engine/gearbox. The regulator ensures that fuel at a correct operating pressure of 3 bar is directed to the fuel injection nozzles, with any excess fuel being returned to the fuel tank.

The fuel pump used in the DeltaJet 500 StingRay has a specified operating life of 2,000 hours. These pumps are reverse locking and can be installed in any position although they benefit from being positioned at tank level as their suction power is limited. The in-line fuel filter and the pump filter are important and should be checked and changed regularly depending on the degree of contamination of the fuel.

If an additional pressure filter is installed in the supply line from the pump to the pressure regulator, it should be changed every 400 hours (or 2 years).

The injection valves are generally maintenance-free. If there are concerns (e.g., a noticeable power drop) which may be due to degraded fuel hoses, the valves must be ultrasonically cleaned or replaced.

8. Bowden cables and Throttle synchronisation

Interval: Check throttle synchronisation every 50 hours and free cable movement every 100 hours or once per year, whichever comes first

8.1 Checking the Bowden cables

Check the integrity of the outer covering of both the foot- and hand-throttle Bowden cables and replace if damaged. To ensure free movement, the cable runs may be lubricated using resin-free grease or oil. Note: If an outer with a Teflon insert has been used, **DO NOT USE A LUBRICANT**.

8.2. Adjustment of the Bowden cables

Important note: Under no circumstances should the adjustment screw (1) be adjusted for the throttle valve stop (body with potentiometer). This is factory set to 0.89-0.92V by interrogating the Trijekt CPU and must not be altered. All adjustments should only be made on the other throttle body.

8.2.1. Checking the pressure difference in idle position.

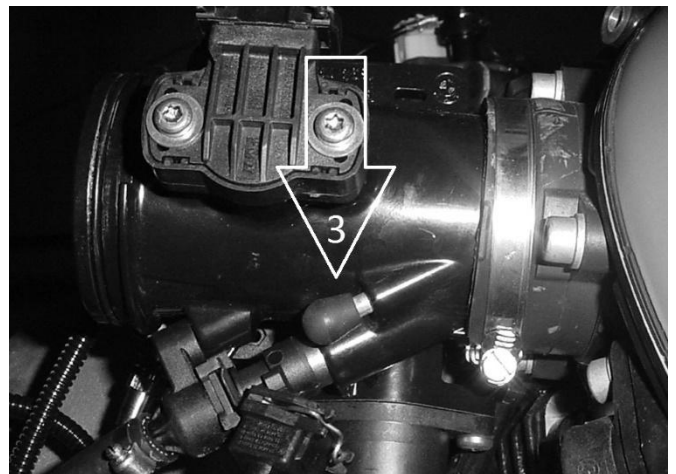
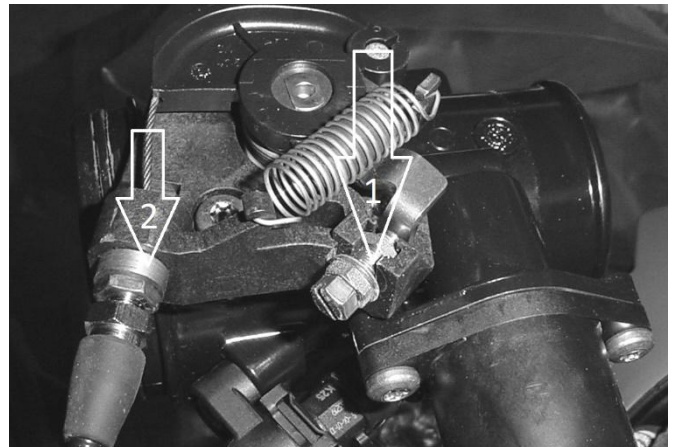
The synchronisation instrument must be connected to the vacuum connection (3). These have rubber caps which should be removed and kept safe.

- 1) The pressure difference between the intake nozzles when the throttle valves are closed in idle mode must not exceed 25 mbar (18.75 mmHg).
- 2) For slightly opened throttle valves (1500-1900 rpm) pressure difference should not exceed 15 mbar (11 mmHg).

If the pressure difference at idle is higher than 25 mbar, the pressure difference can be reduced using the throttle adjusting screw (1).

Remember: Only adjust screw 1 on the throttle body without the potentiometer.

After any adjustment, the screw must be locked and re-marked (preferably with a spot of paint).



8.2.2 Synchronisation of the throttle bodies.

REMEMBER: Under no circumstances must the adjustment screw (1) be adjusted for the throttle valve stop (body with potentiometer).

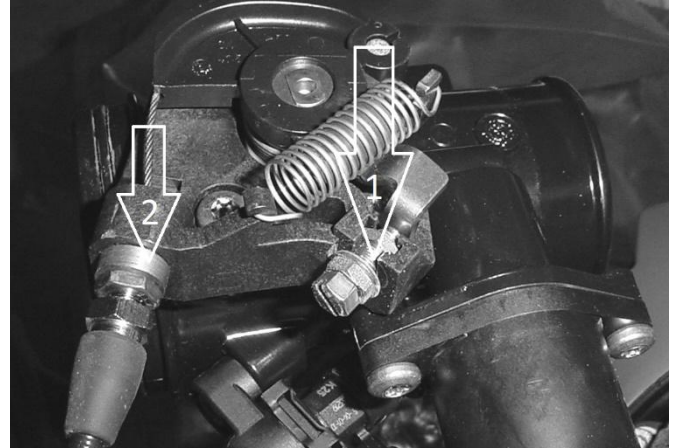
After the idle synchronisation (7.2.1) has been performed, the partial load synchronisation may be performed.

First, check the free movement of the cable is between 1 - 1.5 mm. Adjust if necessary.

Start the engine and set at a constant speed between 1500 - 1900 rpm. Check that the pressure difference does not exceed 15 mbar (11 mmHg).

If the pressure difference is higher, this should be reduced using the adjustment screw (2) of the Bowden cable.

Note: Check that the Bowden cable gap does not reduce to less than 1mm.



Check the setting: The resulting vacuum must always rise or fall evenly at both throttle bodies when switching from idle to 1800 rpm (or more).

Once all adjustments are made, secure the adjustment screw 2 (8 Nm).

Replace the rubber caps on the vacuum connections (3).

Note: Leaking or porous degraded caps may allow air to be sucked in, leading to malfunctioning of the motor. Carefully inspect the caps before replacing them and replace any that appear suspect.

9. Summary/Maintenance

Engine

Oil and filter change – 10 hours, then every 100 hours
 Oil level check – before every flight
 Valve clearance check – 10 hours, then every 200 hours
 Generator belt check – every 100 hours
 Generator belt change – every 200 hours
 Spark plug change – every 400 hours
 Air filters – clean every 100 hours
 Throttle synchronisation – every 50 hours
 Bowden cable free movement check – every 100 hours

Gearbox

Oil change – 10 hours, then every 200 hours
 Basic overhaul – every 400 hours.

Engine Limitations

Max RPM	7500 (5 min) 6000 (continuous)
Oil pressure	Normal 6-7 bar above 2000 rpm Min 0.75 bar below 2000 rpm Oil pressure warning light illuminates at 1.5 bar Max 7 bar
Oil temperature	85 - 135°C
Engine oil spec	Castrol Power 1 4T SAE 10W-40 Alternatively, fully synthetic 5W-50 after first 100h (must be with a filter change)
Gearbox oil spec	Viscosity 140 (e.g., Castrol SAF XJ 75W-140), 250 ml
Fuel spec.	95 RON minimum unleaded to EN 228 Super or Super Plus, AVGAS 100LL, UL91 Unleaded preferred

10. Workshop worksheet

Performed on:	Hours	Work/repairs- Additional sheet y/n	Signature