ADVANCED ROTARY TECHNOLOGY

RT-600-HC
Installation Manual

This document provides the information to allow installation of the RT-600-HC engine into an airframe.

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REVISION RECORD

Revision:	Date:	Revision Approver:	Revision Description:
A	-	-	Initial Release
B	-	-	-
C	19/07/2018	AH	Updated fuel system, Updated oil pre-mix ratio to 30:1
-	-	-	-
-	-	-	-

TABLE OF CONTENTS

1 ACRONYMS

TPS	Throttle Position Sensor
MPS	Manifold Pressure Sensor
2.5D	Denotes simple 3D machining capability
TBD	To Be Defined
AV	Aerial Vehicle
MCP	Max Continuous Power
TOP	Take-Off Power
NDS	Non Drive Side
DS	Drive Side

2 ENGINE DESCRIPTION

The Engine is the first in a planned series of clockwise rotating development engines. It is a gasoline engine with passive ejector cooling, 1.4KW electrical power output and a centrifugal clutch.

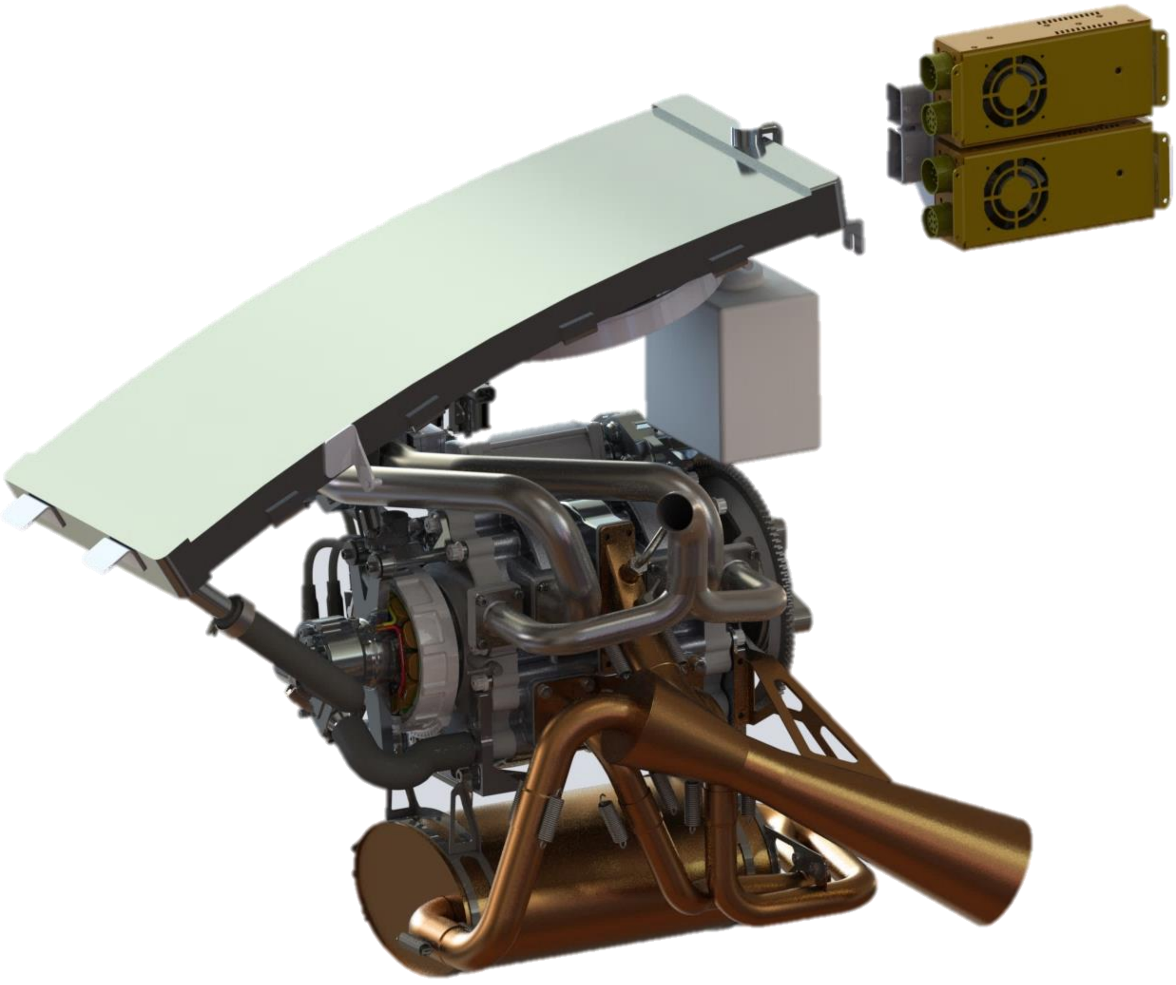


Figure 2.1: Isometric view of engine assembly

The overall engine system is broken down to subsystems that can be seen in Figure 2.2. The corresponding part names and associated mass can be found in Table 4.1, the wiring loom is assumed (depending on integration level) to take the mass up to 39 kg.

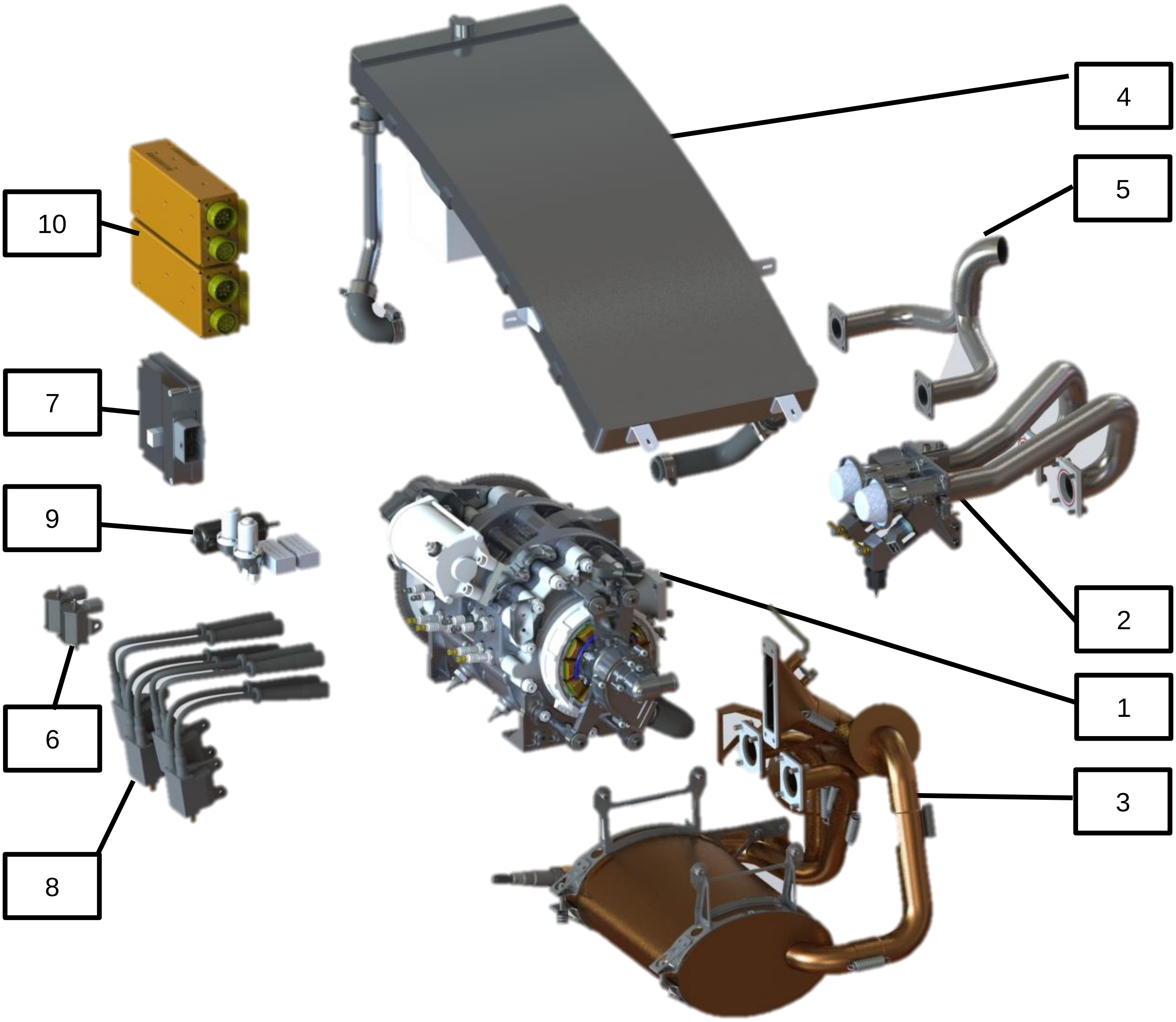


Figure 2.2: Exploded engine assembly

3 ENGINE LIMITS

Table 3.1 Represents the engine operating limits for flight testing in Design Cycle one.

Parameter	Value	Notes
Coolant temperature	•Max 90°C •Min 55°C	Target value 75°C
Air out temperature	•Max 130°C (Continuous) •Min 75°C (Continuous)	Above 145° for more than 1 min without a downward trend becoming apparent abort mission and land as soon as possible.
Fuel pressure	•3 Bar	Tolerance of +/- 0.5 Bar
Ambient air temperature	•Max +45°C •Min 0°C	Minimum set to 0°C for initial engine testing
Altitude	Max 3000 feet	Initial flight envelope due to first engine inception
Starter motor	•Max 29v •Min 24 v	Shut off starter as soon as engine starts. Operate for max of 5 second bursts
Fuel Temperature range	•Max +45°C •Min -20°C	
Oil Temperature range	•Max +45°C •Min -20°C	

Table 3.1: Engine Operating Limits

4 MOUNTING SYSTEM

This section describes the engine interface into the airframe from a mechanical perspective.

4.1 ENGINE WEIGHTS AND INERTIA DATA

4.1.1 ENGINE SYSTEM MASSES

The dry mass breakdown for the main engine system can be found in Table 4.1.

No.	Part	mass (g)	Description
1	RT-A-14757	25427	600 ENGINE BLOCK, CLOCKWISE DRIVE
2	RT-A-14802	1139	INTAKE ASSEMBLY, 600
3	RT-A-14893	3519	EXHAUST V4
4	RT-A-14945	4564	Cooling System Assembly
5	RT-A-14937	193	EJECTOR INLET ASSEMBLY
6	RT-S-10030, X2	293	OIL PUMPS
7	RT-A-15068	277	ECU, WEAF 30
8	IGNITION	943	COILS, CAPS AND LEADS
9	RT-A-15183	645	FUEL SYSTEM
10	RT-S-14938, X2	1300	REGULATORS
-	Wiring Loom	700	WIRING LOOM
	Total	**39000**	

Table 4.1: Propulsion system mass breakdown

4.1.2 SYSTEM INERTIA

The dynamic inertia of the system has been calculated using, Equation 1. Using the offset distance of 11.6mm for the rotor journals and the mass and inertia values drawn from Table 4.2and Table 4.3. The System Inertia about it rotational axis (X-axis) has been calculated to be 18.29 g/m^2.

$$I_{Total} = I_{Balance\ Assembly} + 2[M_{rotor} \times e^2] + \frac{2}{9}[I_{rotor}]$$

Equation 1: Rotating Assembly Inertia

Mass	6626.86	g
COG taken at shaft end, DS		
X	-166.34	mm
Y	0	mm
Z	0	mm
MOI about CG		
Ixx	98.941	g/m^2
Iyy	98.03	g/m^2
Izz	14.056	g/m^2

Table 4.2: Gasoline Rotating Assembly Inertia without Rotors

Mass	2377	g	
MOI - (Rotation about Z-axis)			
Ixx	3.52	g.m^2	
Iyy	3.52	g.m^2	
Izz	5.39	g.m^2	

Table 4.3: Gasoline Rotor Inertia

4.2 ENGINE DRIVE TRAIN TORSIONAL CHARACTERISTICS

The torque curve, derived from mathematical formulae on combustion cycles, can be found in Figure 4.1. The peak load is 138Nm, it is represented as a factor of a single unit on the graph.

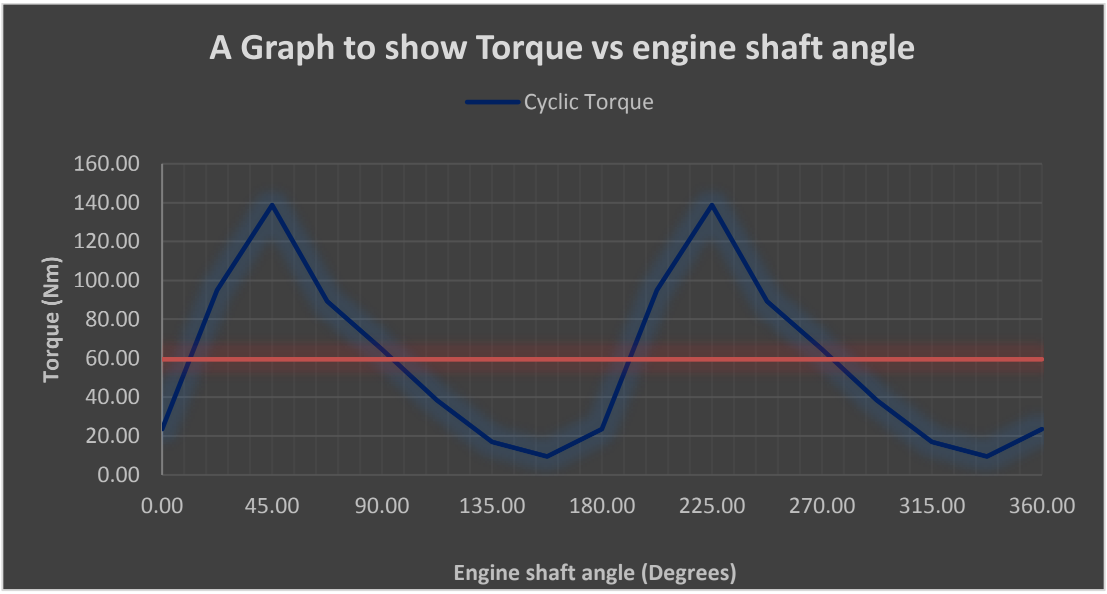


Figure 4.1: Torque curve at 6175RPM

4.3 ENGINE VIBRATION LIMITS

The engines are currently balanced as a rotating assembly to less than one gram for both the NDS and DS. The balancing diameter is dependent on the part however, is usually no more than 130mm. Resulting in a maximum static unbalance of $6.5x10^{-5}$Kgm. With a max operational RPM of 7000RPM results in an imbalance of 35N. Figure 4.2 shows the assembly balanced about the centre axis.

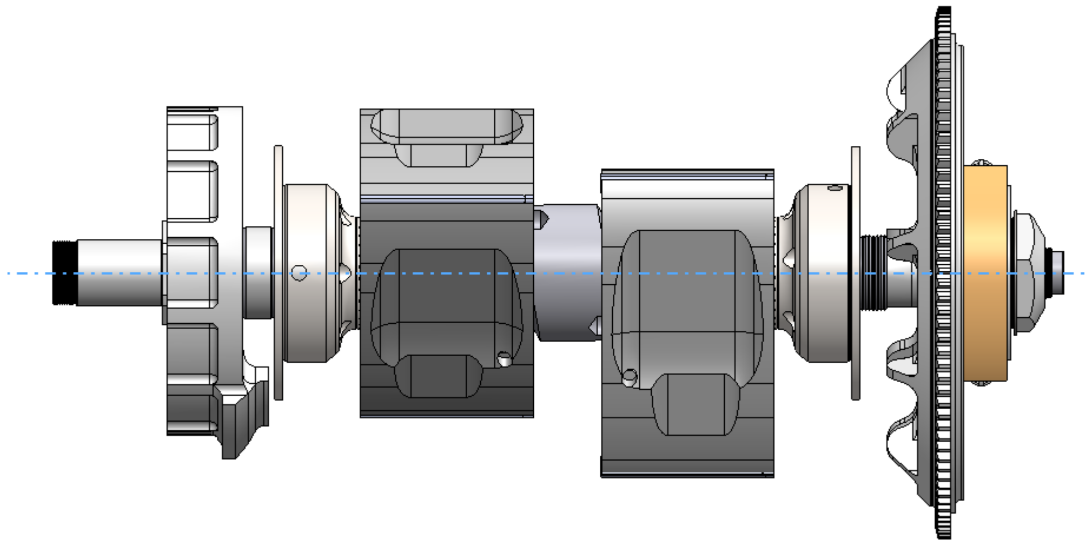


Figure 4.2: Balanced Assembly with axis

4.4 GYROSCOPIC FORCES

The maximum induced moment that is acceptable is 5240Ixx, where Ixx is the inertia of the rotating system about the engines X-axis.

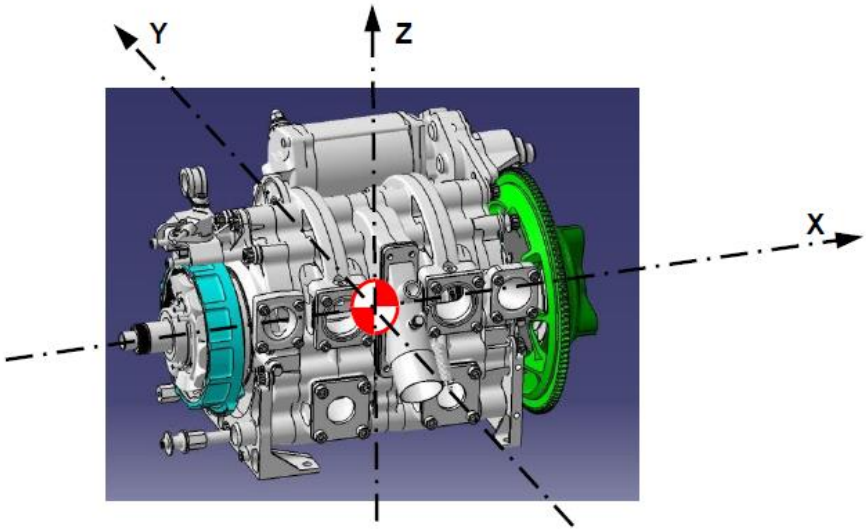


Figure 4.3: Engine 3D Axis

5 AIR INLET SYSTEM

The customers airframe will govern the engine inlet interfacing for the Rotor intake air, and the ejector inlet air.

6 EXHAUST SYSTEM

The customers airframe will govern the engine exhaust interfacing.

The exhaust has no reliance on the airframe for mounting.

7 FUEL SYSTEM

The fuel system consists of a brushless driven system that is driven from the ECU with an inline controller. The fuel line is 5mm fire resistant hose. The datasheet for the fuel pump can be found in Appendix 1. The target fuel rate for the fuel pumps should be maintained at 600cc to ensure the pressure drop does not impact the injector performance.

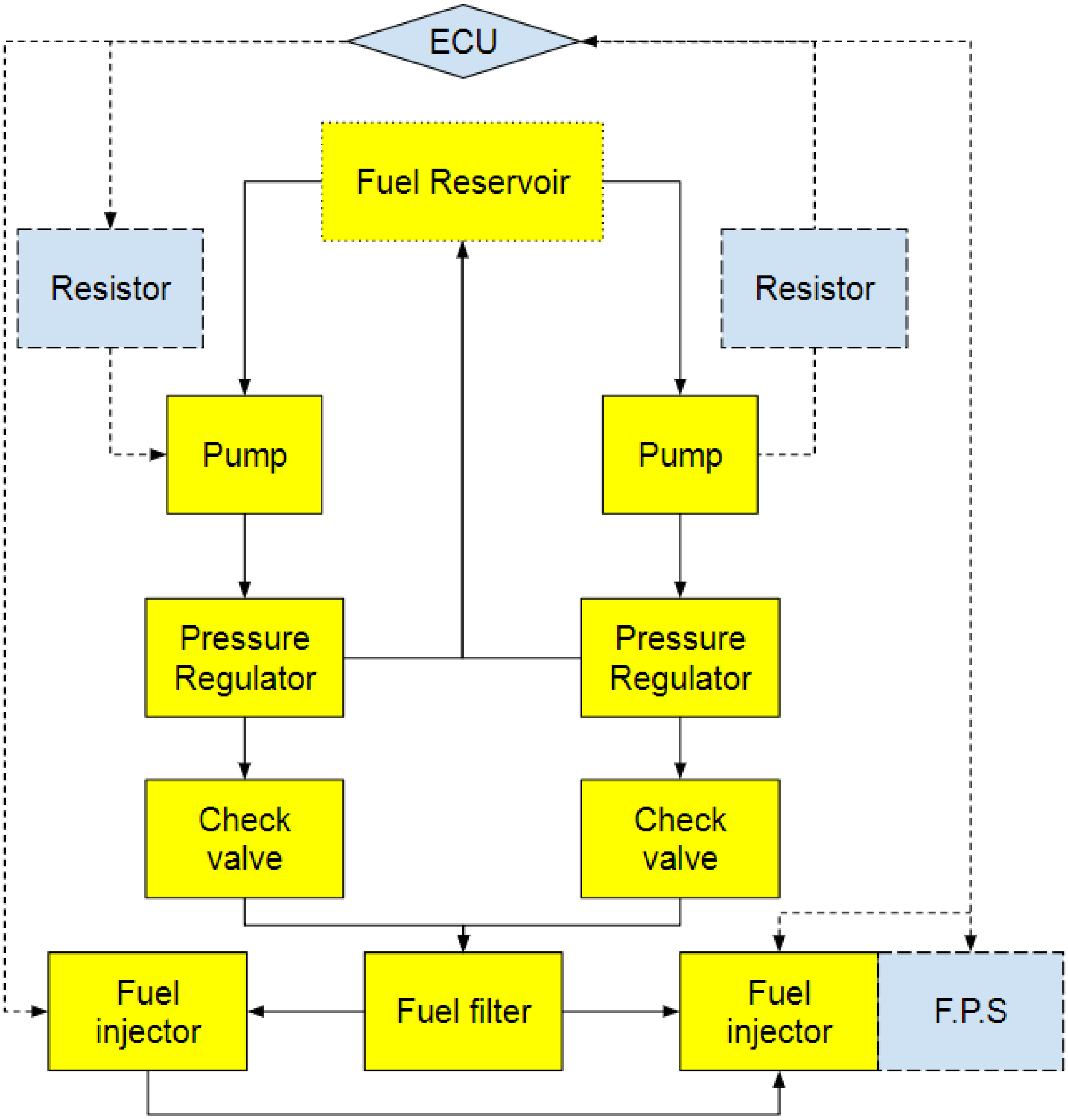


Figure 7.1: Fuel System Diagram

7.1 FUEL AND ADDITIVES

The Fuel qualified for this engine is 95 Ron Unleaded Only.

The fuel is required to be mixed at a ratio of 30:1 (fuel: oil). Please refer to section 9 for information on oil grade.

7.2 FUEL INLET TEMPERATURE

Fuel inlet temperature is covered in Section 3.

7.3 FUEL CONTAMINATION

Although there is an inline fuel filter installed with the engine. Use filtered fuel when filling the fuel reservoir to reduce the risk of contamination to the fuel system. Filter fuel with mesh less than 40 microns.

7.4 AIRFRAME MOUNTED COMPONENTS

The inline fuel filter has a mass of 95 grams and can be assumed to have a CG at the physical centre of the part.

8 ELECTRICAL SYSTEM

For details on the electrical system, please see further electrical interface documentation.

9 LUBRICATION SYSTEM

The oil system is driven by solenoid operated, positive displacement piston pumps. These pumps should be mounted below the reservoir and primed before use to minimise the effects of air bubble contamination. The oil pump datasheet can be found in Appendix 1.

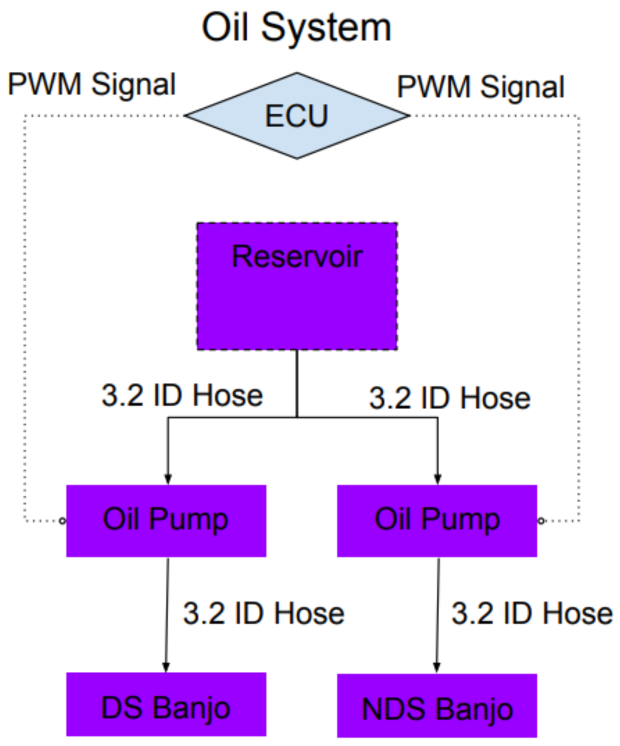


Figure 9.1:Oil System Diagram

9.1 LUBRICATION OIL

The oil qualified for use is Mobil1 Racing 2T (Two Stroke Oil).

9.2 OIL CONSUMPTION

The oil is premixed with the fuel in the rotor housings, (Section 7.1). It is also run into the bearings on the front face of the engine, port side. The average total oil consumption rate for the bearings is 7ml/min or 420ml/hr.

9.3 OIL INLET TEMPERATURE

The oil inlet temperature has been defined in Section 3.

9.4 OIL CONTAMINATION

Pre-filter the oil with a mesh that is less than 40microns in size.

10 COOLING REQUIREMENTS

The engine is controlled via a thermostat and temperature switch. The thermostat mechanically bypasses cooling flow to skip the radiator, allowing the engine to heat up at a faster rate. The temperature switch controls the fan operation under the radiator. This does the opposite of increasing the cooling rate of the radiator by increasing the mass flow over the radiator.

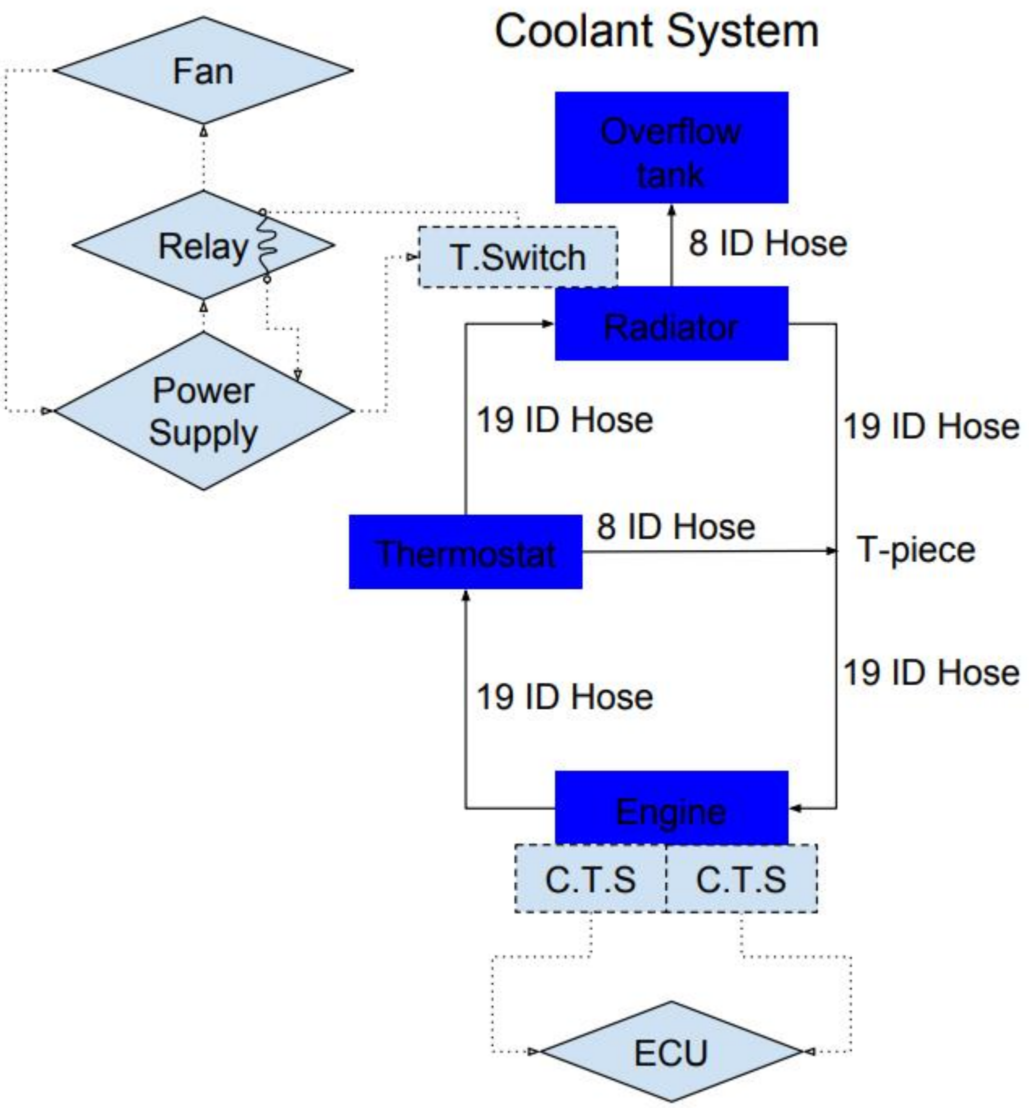


Figure 10.1: Coolant System Diagram

10.1 ENGINE COOLING

Operation ranges and targeted temperatures can be found in Table 3.1.

10.2 AIRFRAME MOUNTED COMPONENTS

The radiator position is controlled via its curved profile and its mounting points to the airframe. The overflow tank is currently subject to location. The dry mass of the overflow tank is 150 g.

11 ENGINE PERFORMANCES

The engine has a TOP of 51.5HP (38.4KW) at 6175 RPM. How the RPM effects the horse power is subject to testing of the first configuration.

The SFC of the engine should be considered as 450g/KW-Hr.

11.1 PERFORMANCE VARIATION WITH ALTITUDE AND TEMPERATURE

The perfromance can be found at altitude by knowing, the base power (PWR in [HP]), altitude (ALT in [feet]) and temperature (TEMP in [Kelvin]).

$$C.PWR = PWR\left[\left[1-\frac{(1.9812\times10^{-3})ALT}{288}\right]^{5.2561}\sqrt{\frac{288}{TEMP}}\right]$$

Equation 2: HP at Altitude

The base power can be taken as MCP and plotted with the different variables. This equation can be plotted out to give a 3D graph of how the engine power varies

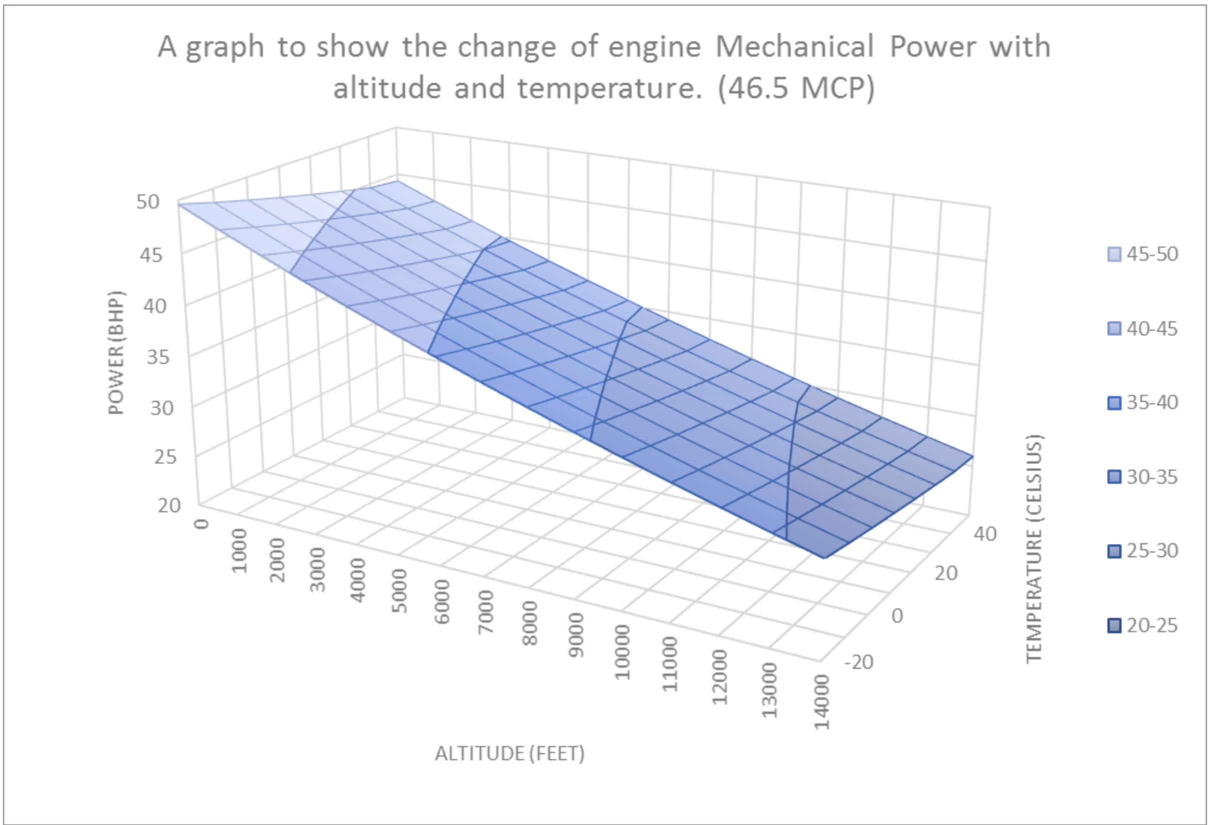


Figure 11.1: MCP of Engine over varied operating environments

12 INTERFACE CONTROL

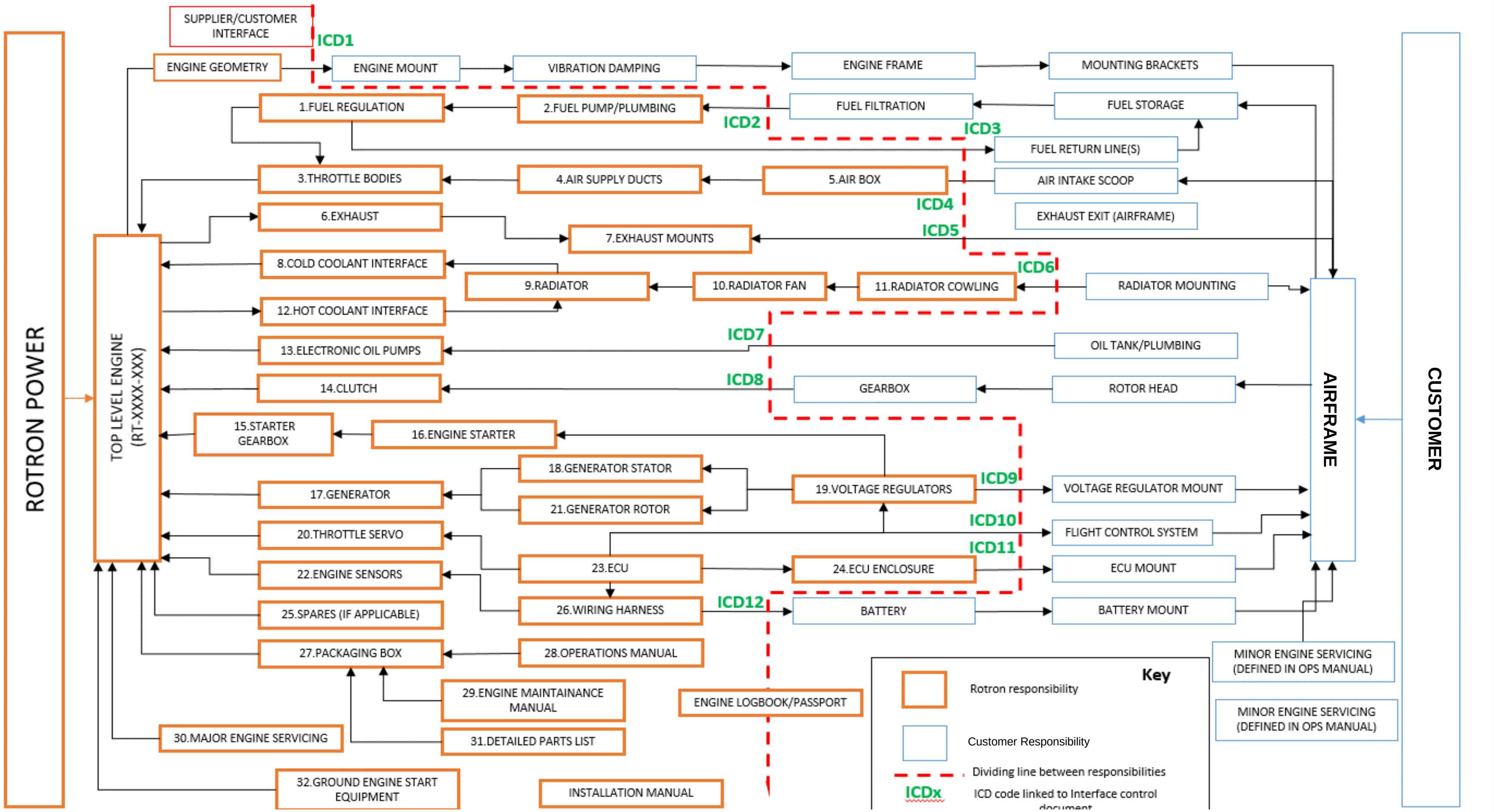


Figure 12.1: Interface Control Overview

APPENDICES

APPENDIX 1

MGD1000 F - Data Sheet

TCS Micropumps

Micro Gear Liquid Pump Range

Overview : High Pressure Pump Range, Self Priming, Brushless Drive

The MGD1000 series micopump, delivers consistent pulseless flow with high or low pressure. They are suitable for a wide range of liquids and are self-priming. The MGD1000 can be used with all common liquids and will also resist most chemicals and solvents. The pump has two connection options; stainless steel threaded tubing connectors for quick and easy connection to tubing, or for directly mounting to your manifold. Its flow direction is reversible.

Delivering a smooth consistent, almost pulseless flow, throughout the pressure range, these pumps are particularly suitable for systems where pressure and flow consistency are key requirements.

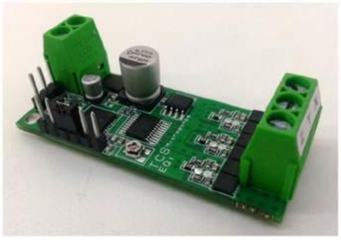
Features

- High pressure capability
- Self-priming
- High and low viscosity liquids
- Smooth almost pulseless flow
- Reversible flow
- High chemical resistance
- Small size only 65 x 32 x 30 mm
- 1/8 bsp Connectors or Manifold
- No dynamic seal

* Important *

These motors require a separate controller to operate!
The MGD1000 pump range utilizes high performance, efficient sensorless brushless motor technology.

TCS Micropumps offer the EQi range of controllers for this purpose.



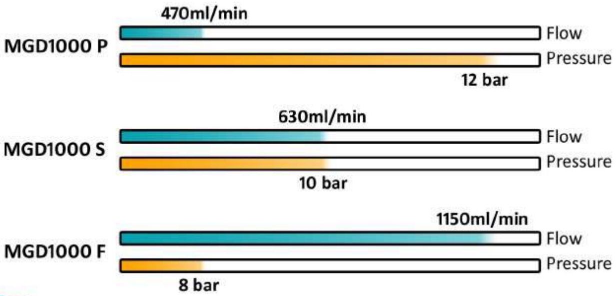
Typical Applications

- Dosing
- Medical devices
- Fuel Cells
- High Pressure Fuel Pump
- Cooling Systems
- Precision Flow
- Lubrication systems

MGD1000 Pump Options Data

The TCS MGD1000 range come in 3 different options that can make your pump more suited to your needs. Standard, Pressure & Flow.

All MGD1000 pump variants are capable of more than the indicated figure but exceding this may result in damage to the pump.



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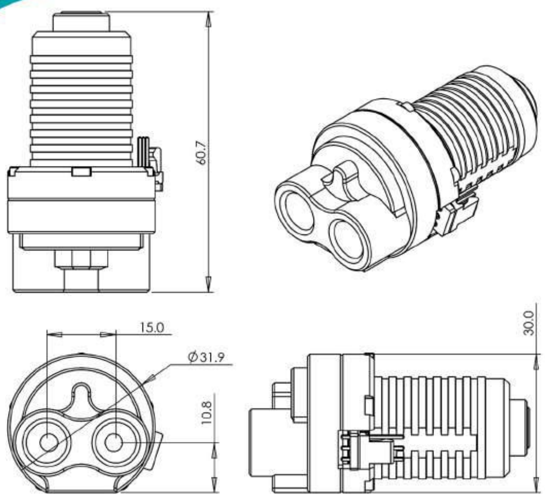
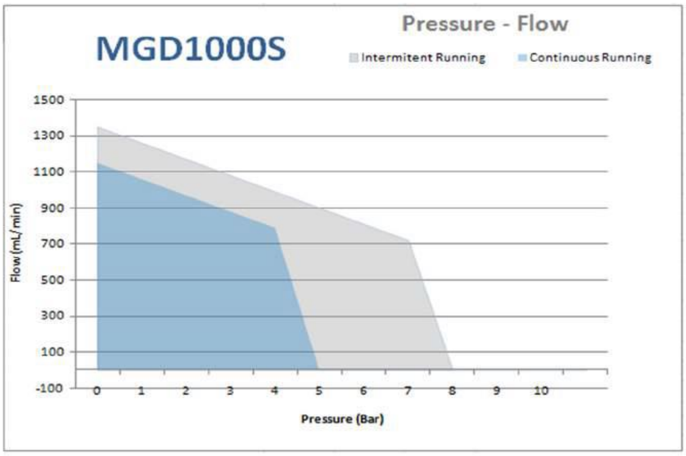
DS31 Page 1 Rev 1.

MGD1000 F - Data Sheet





Customising and Tailoring your Pump

TCS can offer you variants of any stock pump, to suit your requirements. If you need other seal options, materials, specfic performance etc, TCS can configure pumps and systems or provide new, unique solutions developed and tailored exactly to your needs.

New variants and concepts are also designed and developed to suit specific customer requirement by the TCS in-house design and development unit.

If you have a specific requirement that demands a unique pump or system then get in touch.

Technical Data

- Size — 65 x 32 x 30mm
- Weight (exclduing connectors) — 110 g
- Maximum Free Flow — 1150ml/min
- Operating Temp - High — 100 °C
- Operating Temp - Low — -80 °C
- Max Viscosity — 5,000 cSt
- Max Differential Pressure (Continuous) — 4 Bar
- Max Differential Pressure (Intermittent) — 8 Bar
- Max System Pressure — 100bar+
- Max Continuous Current — 1.8A
- Wetted Parts: 316 Stainless Steel, PEEK, Ertalyte,Viton
- Fluid Connection - Standard — 1/8bsp (female)
- Fluid Connection - Manifold — (see web for details)
- Typical Life — >20,000hrs
- IP Rating - Standard pump — IP45
- IP Rating - Waterproof version — IP67
- Intergrated drive motor — Sensorless Brushless
- Motor Control Type — Brushless Driver required
- Electrical Connections
  - Standard Version - TE MTA-100 3/1 Connector
  - Waterproof Version - Stripped wires
- Lead Length — 220mm
- Filter Recomendations — 10microns
- Noise Levels — (above ambient 50db at 1m) 15dB

Document Ref No.
DS31 Page 2 Rev 1.

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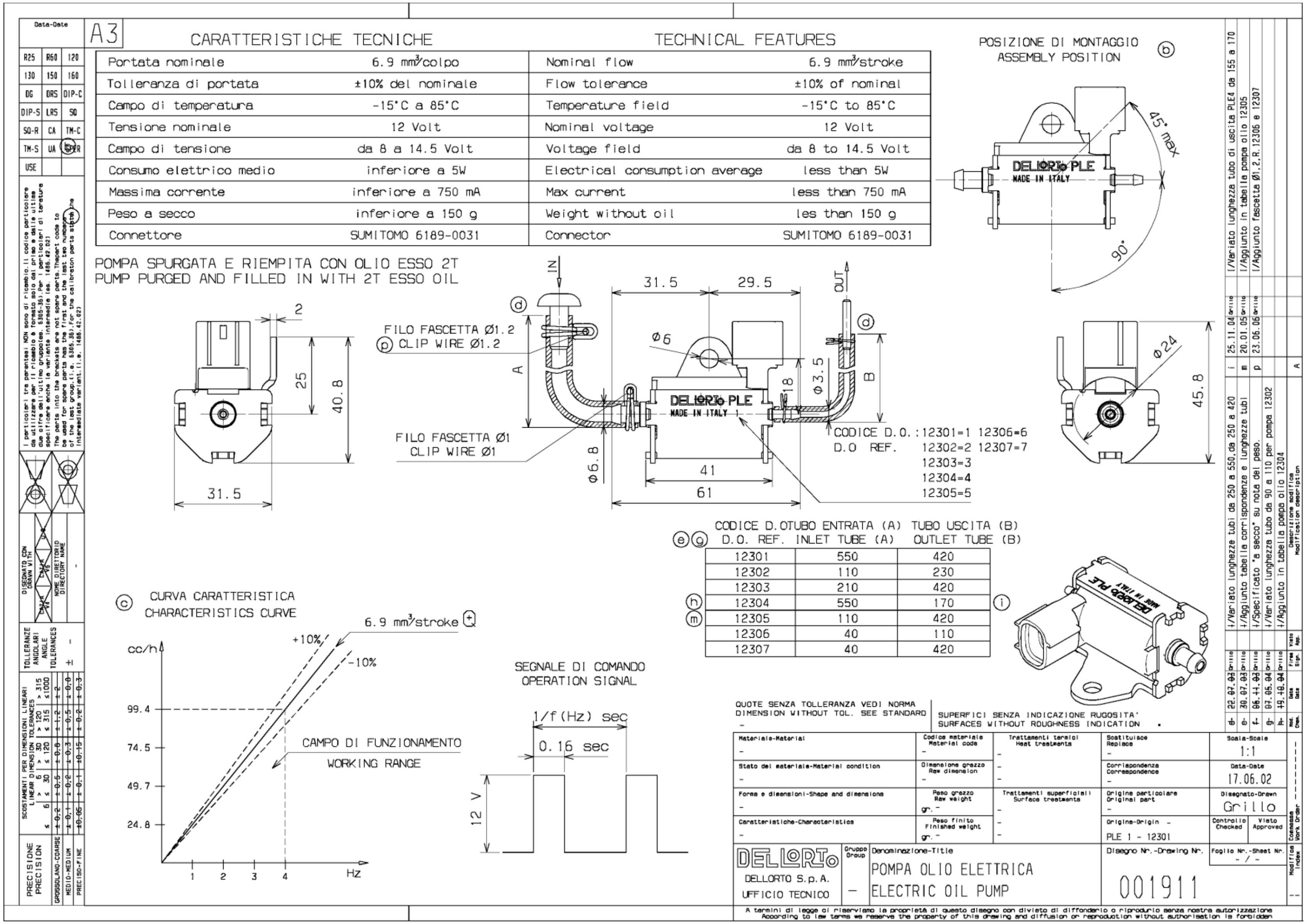
ROTRON



CARATTERISTICHE TECNICHE		TECHNICAL FEATURES	
Portata nominale	6.9 mm³/colpo	Nominal flow	6.9 mm³/stroke
Tolleranza di portata	±10% del nominale	Flow tolerance	±10% of nominal
Campo di temperatura	-15°C a 85°C	Temperature field	-15°C to 85°C
Tensione nominale	12 Volt	Nominal voltage	12 Volt
Campo di tensione	da 8 a 14.5 Volt	Voltage field	da 8 to 14.5 Volt
Consumo elettrico medio	inferiore a 5W	Electrical consumption average	less than 5W
Massima corrente	inferiore a 750 mA	Max current	less than 750 mA
Peso a secco	inferiore a 150 g	Weight without oil	les than 150 g
Connettore	SUMITOMO 6189-0031	Connector	SUMITOMO 6189-0031

CODICE D.O. / D.O. REF.	TUBO ENTRATA (A) / INLET TUBE (A)	TUBO USCITA (B) / OUTLET TUBE (B)
12301	550	420
12302	110	230
12303	210	420
12304	550	170
12305	110	420
12306	40	110
12307	40	420

ADVANCED ROTARY TECHNOLOGY

RT-600-HC Operating Limits and Procedure

Document to detail the operating procedure, pre-flight checks and operating limits of the 600 gasoline engine.

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REVISION RECORD

Revision:	Date:	Revision Approver:	Revision Description:
A	08/10/18	Mark Burley	First Issue
B	07/11/18	Claire Johnson	• Technical Data section added • Additions made to Section 6 limits • Changes made to limits in Section 6
C	26/11/18	Mark Burley	• Introduction added • Engine monitoring and tuning section added (Section 4) • Engine stop procedure updated (Section 5) • Section 8 removed • ECU power on time limit removed
D	27/11/18	Mark Burley	• Coolant operational limits updated
E	15/07/19	Alan Saunders	• Contents page added • Pre-flight checks updated • Operating limits and mitigating action updated • Maximum operating temperature increased to 45°C & 28°C moved to a Recommended Maximum
F	20/08/19	Alan Saunders	• Engine Ground Notes section added • Lambda sensor operation statement added

CONTENTS

1 INTRODUCTION

This manual must be followed for safe operation and tuning of the Rotron 600cc gasoline engine supplied in helicopter format.

The contents of this manual are important and any deviations from the instructions could result in unsafe operation of the engine which may result in damage to the system, equipment or injury to personnel.

Please contact Rotron with any queries regarding safe operation of the engine.

2 PRE-FLIGHT CHECKS

This section of the document lists the pre-flight and sensor checks (Table 2-1) which must be carried out before operation of the engine.

Table 2-1: Pre-Flight Checks

Physical checks for loose mounts:	
1.	Engine mounts are tight
2.	Exhaust fixings are tight with no cracks on the exhaust, and all springs present including ejector pipe fixings (see drawing RT-A-14975 for torque settings)
Fluid and leak checks:	
1.	Coolant radiator is full and no coolant leaks are present
2.	Ensure oil lines are correctly bled during installation and oil reservoir is full, with no oil leaks present on lines or at any joints. Pump operation shall be checked during installation to ensure fluid is flowing to banjos.
3.	No fluid leaks from engine and all bolts have been visually checked
Sensor checks:	
1.	All sensors are working correctly and displaying expected values as below including no CAN error messages present
2.	All fuel line connections should be checked for a correct fit during installation. Ensure no CAN error messages detailing fuel system leaks, pump failure or injector failure during ECU fuel pump checks
Documentation:	
1.	Ensure maintenance schedule has been kept up
2.	Ensure that the Engine Passport has been completed and the required maintenance has been undertaken

ENGINE RUNNING IS NOT PERMITTED UNLESS PRE-FLIGHT CHECKS ARE COMPLETED AND SUCCESSFUL.

2.1 EXPECTED SENSOR VALUES

Table 2-2 lists the expected sensor values when engine is cold.

Table 2-2: Pre-Flight Sensor Values

Coolant Temperature	Ambient temperature
Air Temperature	Ambient temperature
Rotor Air Out Temperature	Ambient temperature
MAP Sensor	Ambient pressure
Fuel Pressure	0 bar prior to priming fuel pumps

3 TECHNICAL DATA

This section details the fluid requirements of the engine including fuel pre-mix, lubrication, coolant and air filtration.

3.1 FUEL & PREMIX REQUIREMENTS

Fuel	95 RON Unleaded Gasoline
Fuel Filter	40 Microns
Fuel Supply Rate	Rotron Defined Fuel Map
Premix Ratio	50:1
Premix Oil	Mobil 1 Racing 2T
Premix Oil Filtration	Less Than 40 Micron Filter Upon Installation

3.2 LUBRICATION REQUIREMENTS

Lubrication Oil	Mobil 1 Racing 2T
Lubrication Oil Supply Rate	Rotron Defined Oil Map
Lubrication Oil Filtration	Less Than 40 Micron Filter Upon Installation

3.3 COOLANT REQUIREMENTS

Coolant	Water
Coolant Mixing Medium	Ethylene Glycol
Recommended Mixing Medium	Comma Super Coldmaster Antifreeze
Coolant Mixing Ratio	50:50
Coolant Filtration	Less Than 40 Micron Filter Upon Installation

3.4 AIR FILTRATION REQUIREMENTS

Air Filtration	Rotron Supplied

4 STARTING ENGINE AND ENTERING FLIGHT MODE

1. Power on ECU, fuel pumps and injectors.
   Fuel pumps and injectors must be powered on before ECU, if on separate power supply due to fuel pump check running immediately once ECU is powered up.
2. Check for fuel pump error messages.
   (If error messages are found then the issue must be solved, and the power to the ECU cycled to check the issues have been corrected.) *See reference TD-0001 for CAN error messages IDs.*
3. Ensure power is on to all ancillary components.
4. Send START CAN command and ENABLE discrete signal simultaneously, for a minimum of 0.5 seconds.
   Engine should fire within 3 seconds otherwise a failed start error message will be sent. (A failed start is classified as an engine that cannot maintain constant running for more than 20 seconds. The engine can be restarted an additional three times (total 4) before the spark plugs must be replaced. Additionally, if the engine fails to start before the fourth attempt and still retains some heat but has fallen below the lower limit of 70°C coolant temperature; this is also classified as a failed start and the spark plugs must be replaced.)
5. Send IDLER CAN command and ENABLE discrete signal simultaneously, for a minimum of 0.5 seconds once started.
6. Allow to idle until temperature is 80 ℃, or a minimum of 1 minute
7. Send WARM UP CAN command and ENABLE discrete signal simultaneously, for a minimum of 0.5 seconds once ready to enter warm up phase.
   - *No critical engine conditions are required to enter warm up phase from idler.*
8. Wait within the WARM UP stage for a minimum of 30 seconds
9. Send FLIGHT CAN command and ENABLE discrete signal simultaneously, for a minimum of 0.5 seconds once ready to enter flight phase.
   - *Engine will only enter Flight state if coolant temperature is greater than 50°C and is currently in warm up state.*
   - *When at governor speed with zero collective temperatures will increase, add collective to cool engine*

5 ENGINE MONITORING & TUNING

Figure 5-1 shows the display screen that must be used to monitor the engine parameter and performance.

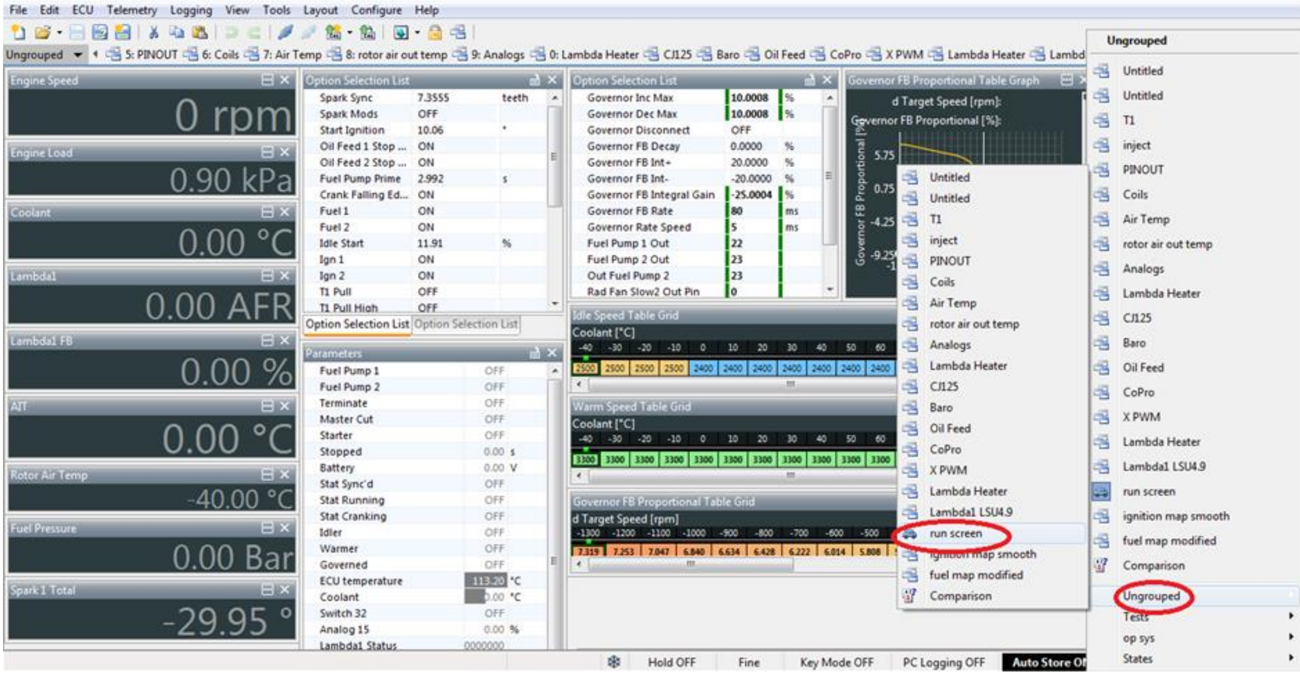

Figure 5-1: Engine Monitoring Display

Figure 5-2 shows how the idle and speeds can be set by adjusting the values within the red boxes.

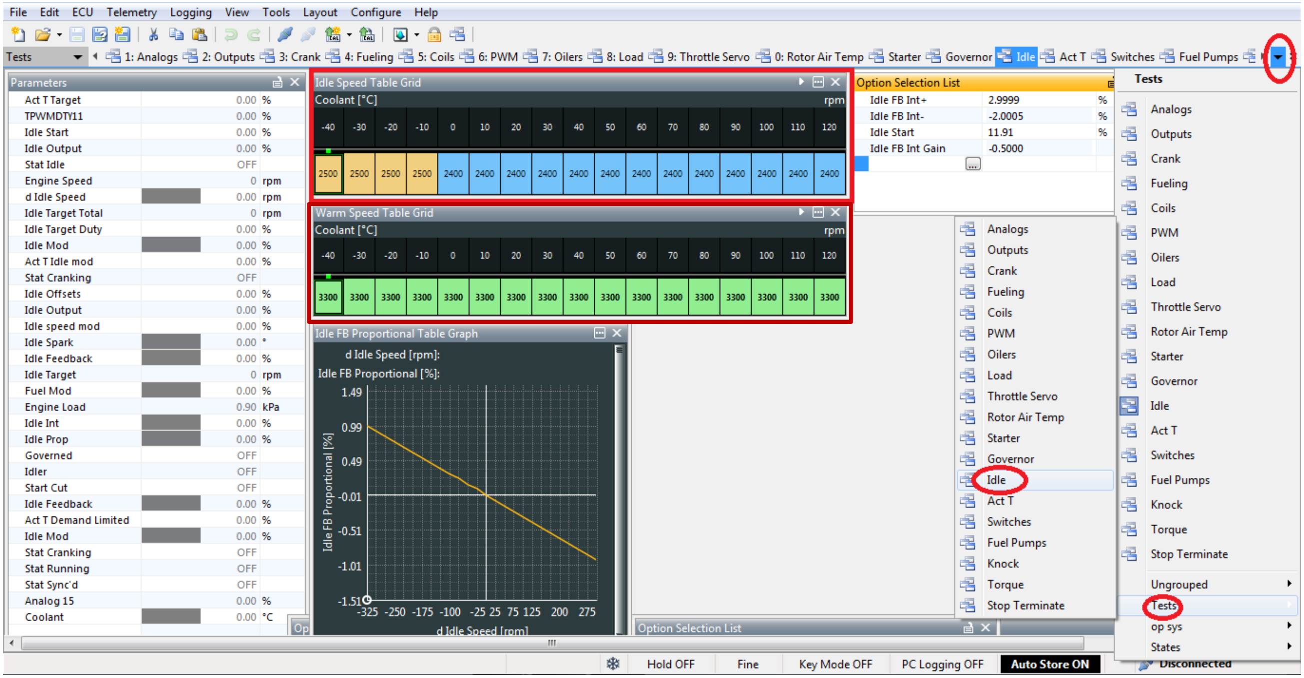

Figure 5-2: Idle and Warmer Settings

Please note, it is advisable that the warmer speed is constant for all temperatures.

Figure 5-3 shows the governor display screen that must be used for tuning.

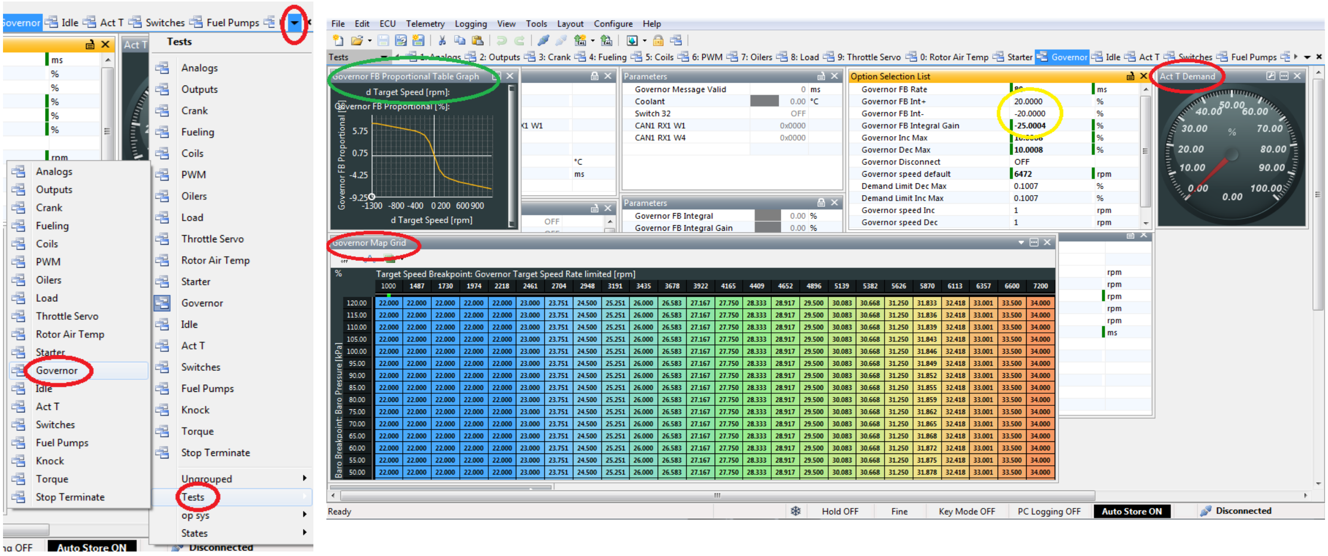

Figure 5-3: Governor Tuning

The **Governor Map Grid** (circled above) shows the initial throttle value for a given speed and barometric pressure which the ECU requires for the translation of **warmer to governor**. This value relates to the **Act T Demand** (circled top right) which drives the throttle servo.

The **Governor FB Proportional Table Graph** (circled top left in green) is the difference between the **set speed** and the **current speed**. The **change of throttle travel ratio** is based on this engine speed difference. A steeper curve will result in a bigger throttle change for a given speed difference.

The **Governor FB Integral Gain** (circled in yellow) defines how the difference between **actual rpm** and **set rpm** throttle values are applied. A larger Integral Gain value will mean the value from FB Proportional will be applied at a faster rate.

Table 5-1 provides a summary of parameter and their definitions.

Table 5-1: Engine Monitoring and Tuning Parameters

Parameter	Definition
Gov Fb Int +/-	Rate of change limits
Governor Speed Default	Engine speed when set to governed
Barometric Pressure	Barometric pressure (Measured by ECU)
Act T Demand	Controls the servo throttle (%)

Note: It is advised that changes in small increments (In the order of 1% per change) are made. Large changes could result in catastrophic speed oscillations and engine damage.

The flow diagram below shows how parameters interact.

Figure 5-4: Governor Control Flow Diagram

6 STOPPING THE ENGINE

1. Send WARM UP CAN command and ENABLE discrete signal simultaneously, for a minimum of 0.5 seconds once ready to enter warm up phase.
2. Wait and allow the temperature to stabilise, this must allow the cooling fan to cycle at least once
3. Send IDLER CAN command and ENABLE discrete signal simultaneously, for a minimum of 0.5 seconds to enter IDLER state.
4. Send STOPPER CAN command and ENABLE discrete signal simultaneously, for a minimum of 0.5 seconds.
   Engine will only stop if command is sent while in idle state. Engine should be allowed to idle for 2-5 minutes and coolant temperature less than 87°C before sending command.

7 IN CASE OF EMERGENCY

To stop the engine from any state, the ARM and TERMINATE discrete signals must be sent simultaneously for a minimum of 0.5 seconds.

8 OPERATING LIMITS

Table 8-1 provides a list of the operating parameters which **shall** not be exceeded whilst running the engine and provides a list of mitigating actions.

If operation outside of the specified limits occurs the engine warranty will become void and non-compliance to the operational limits can result in uncontrollable air vehicle operation, damage to air vehicle and serious injury or death to personnel.

Table 8-1: Operating Limits & Mitigating Actions

Parameter	Operating Limit	Mitigating Action
Engine Power	•Max 54 HP within the engine speed range of 5866-6485 RPM.	Maximum power must not be operated for a period greater than 5 minutes at a time, with a minimum of 5 minutes at a lower power rating between each maximum power cycle.
Maximum Throttle Percentage	•Max 50%	If maximum throttle percentage is exceeded abort the mission and ground the Air Vehicle immediately pending inspection of engine.
Engine Operating Speed	•Instantaneous Max up to 6920 RPM •Normal Operation 5866-6485 RPM •Min 2500 RPM	If operating outside of the specified parameters action should be taken by pilot to return to the operating range. If not successful within 1 minute abort mission and ground Air Vehicle immediately.
Coolant Temperature in Idle/Warmer	• Instantaneous Maximum - 100 °C • Continuous Maximum - 95 °C for 1 minute	If coolant temperature remains at, or above, the maximum value for over 1 minute or exceeds instantaneous maximum temperature the mission must be aborted, and the issue rectified.
Coolant Temperature in Governed	•Maximum - 90 °C •Minimum - 55 °C*	Minimum limit applies when the engine is in the governor function of the ECU and is ready for flight. If the temperature exceeds these limits for over 1 minute the Air Vehicle must be grounded immediately.
Rotor Air Out Temperature (RAOT)	•Max 135°C* (Continuous) •Min 75°C (Continuous)	If RAOT is above 145°C for more than 1 minute without a downward trend becoming apparent the Air Vehicle must be grounded immediately.
Fuel Pressure	•Instantaneous Max 5 Bar •Normal Operation 3 Bar +0.3/-0.15 Bar	If the fuel pressure is below the operating limit for more than 1 minute the mission must be aborted and the Air Vehicle grounded immediately. If the fuel pressure reaches or exceed the instantaneous maximum pressure the mission shall be aborted, and the Air Vehicle landed.
Ambient Air Temperature	•Max +45°C •Recommended Max +28°C* •Min 0°C	Minimum set to 0°C for initial engine testing *For the Recommended Maximum temperature with curved radiator (RT-M-14912) & one cooling fan (RT-S-14962), operation above this temperature is acceptable assuming that the coolant temperature limits are noted & followed. *Due to the lack of test data on the cooling of the engine in the application Rotron would advise that 28*°C is maximum ambient temperature.
Altitude	Max 1400 feet	Initial flight envelope due to first engine inception. Rotron must approve any plans to operate outside of the specified altitude range.
Starter Motor	•Max 29V •Min 24V	Operate starter motor for a maximum of 5 seconds with 30 second intervals between each operation. Do not

Parameter	Operating Limit	Mitigating Action
		attempt start more than 4 times consecutively. After 4 starting attempts the Spark Plugs must be replaced and wait a minimum of 10 minutes before attempting to start again. The staring procedure must be followed.
Fuel Temperature Range	•Max +45°C •Min 0°C	If fuel temperature is outside operational limits for more than 5 minutes, the mission must be aborted (and Air Vehicle grounded if in flight).
Oil Temperature Range	•Max +45°C •Min 0°C	If oil temperature is outside operational limits for more than 5 minutes, the mission must be aborted (and Air Vehicle grounded if in flight).
Maximum Regulator Temperature	• Instantaneous - 80 °C • Maximum - 75°C	Maximum temperature shall not be exceeded for a period of 5 minutes or the mission shall be aborted (and Air Vehicle grounded if in flight). *This temperature shall be monitored in the same location as the temperature stickers on the surfaces on the sides of the regulators*
Lambda	•Max 1.00 •Min 0.86	If Lambda is outside of operational limits for more than 1 minute the mission shall be aborted and Air Vehicle grounded.

9 ENGINE GROUND NOTES

9.1 LAMBDA SENSOR OPERATION

When the vehicle is on the ground without the engine running, the lambda must not be left powered on for no longer than 5 minutes. **Doing so will result in damage to the sensor.**

If power to the system is required for longer than 5 minutes, then the Lambda sensor must be disconnected.

ADVANCED ROTARY TECHNOLOGY

RT-600-HC
Maintenance Manual

Use of this document should provide clear steps which when followed will ensure RT-600-HC is correctly maintained during operation.

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REVISION RECORD

Revision:	Date:	Revision Approver:	Revision Description:
A	28/09/18	Ray King	-
B	21/09/20	Alex Head	-

CONTENTS

ABBREVIATIONS & DEFINITIONS

µm	-	Micrometers / Microns (1/100,000,000 metre)
AST	-	Apex Spring Travel
Doc	-	Document
DS	-	Drive Side
i.a.w.	-	In Accordance With
i.e.	-	Id Est (Literally 'That Is')
MEK	-	Methyl Ethyl Ketone
mL	-	Millilitres
mm	-	Millimetres
NDS	-	Non-Drive Side
Nm	-	Newton Metre
Ref	-	Reference

1 DOCUMENT PURPOSE

This document is intended to detail the maintenance which the customer must complete at the scheduled intervals to be able to operate the engine.

2 PERIODIC MAINTENANCE SCHEDULE

When operating ensure that the procedures detailed up to this section have been followed to avoid damage to the engine and invalidation to any warranty claims.

Table 2-1 – Engine Maintenance Requirements for Regular Use.

Interval	Action	Reference Document
Every 50 hours	1. Replace all spark plugs 2. Apex spring travel check 3. Clean air filter	Section 5.1 Section 5.2
Every 250 hours	1. Replace Fuel Filter	-
Every 250 hours	1. Return engine to Rotron for overhaul	-

3 IRREGULAR MAINTENANCE SCHEDULE

This section shall detail the portion of maintenance that could be considered irregular, i.e. storage conditions.

Note, a period of time that would be considered storage would be;

- Any period of time over 2 weeks (14 days) with the engine installed in the airframe without engine operation.
- Any period in which the engine is removed from the airframe for maintenance and is not installed in the airframe again within 1 week (7 days).

Table 3-1 – Engine Maintenance Requirements for Before Storage.

Before Storage Actions		
Action	**Description**	**Note**
Remove all coolant	All coolant shall be removed from the engine by draining it by removing the lowest hose of the NDS side plate	Coolant shall be disposed of i.a.w. local environmental legislation and all hazards on coolant handling are to be observed.
Inject engine assembly lubricant	Inject generous amount of engine assembly lubricant into the exhaust port and turn over the engine by hand for a minimum of 1800° (5 rotations) of shaft angle	
Remove inlet system and cover intake ports	Cover air inlets with impermeable barrier (i.e. tape) to prevent ingress of particulates into the engine.	*Only to be completed if outside airframe*
Remove exhaust system and cover exhaust ports	Cover exhaust outlets with impermeable barrier (i.e. tape) to prevent ingress of particulates into the engine.	*Only to be completed if outside airframe*
Clean engine externals	Clean the exterior of the engine with degreaser and agitate with suitable brush & lint free cloth.	MEK & Trichloroethylene are not recommended.
Spray engine with corrosion inhibitor	Spray all exterior surfaces of the engine with a corrosion inhibitor (i.e. Rocol Clear 400 ml Aerosol Rust & Corrosion Inhibitor) i.a.w. manufacturer's instructions on container.	

Table 3-2 – Engine Maintenance Requirements for After Storage.

After Storage Actions			
Action	**Description**	**Note**	**Ref Doc**
Clean engine externals	Clean the exterior of the engine with degreaser and agitate with suitable brush & lint free cloth.	MEK & Trichloroethylene are not recommended.	
Refill with new coolant.	Refill engine with new mixed coolant, mixed as per the operations manual.		
Uncover & clean all mounting surfaces	Remove all coverings & clean intake and exhaust mounting surfaces.		
Install all ancillaries	Install all ancillaries i.a.w. Rotron drawing requirements.		

4 SPECIAL MAINTENANCE ACTIVITIES.

Table 3-1 – Special Maintenance Activities.

Interval	Action
When intake or exhausts are removed	Cover ports with impermeable barrier to ensure no foreign objects can enter engine.
After every flight in salt water rich environment	1. Clean engine externals with fresh water 2. Spray all exterior surfaces of the engine with a corrosion inhibitor, (i.e. Rocol Clear 400 ml Aerosol Rust & Corrosion Inhibitor).

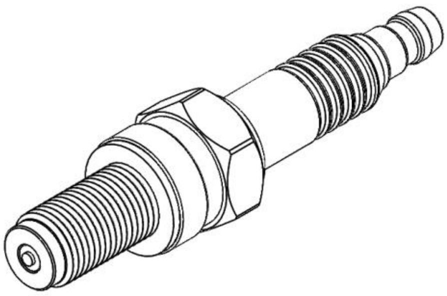
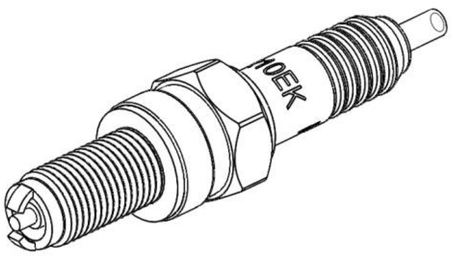
5 MAINTENANCE INSTRUCTIONS

5.1 SPARK PLUG REPLACEMENT

The leading and trailing spark plugs are of a different design. If the incorrect spark plugs are fitted in the housing, severe damage to the engine can result. A visual representation of the spark plug designs is provided in Table 5-1.

- Remove the spark plugs with a long reach 16mm spark plug socket.
- Install a new set of spark plugs ensuring that the integrated sealing washer is installed and free from damage.
- Thread component in by hand until it contacts the housing.
- Torque spark plug to 12Nm.

Table 5-1 – Spark Plug Types.

Part Number	Description	Image
RT-S-16697	SPARK PLUG, SURFACE DISCHARGE *(Leading Spark Plugs)*	
RT-S-16696	SPARK PLUG, DUAL ELECTRODE *(Trailing Spark Plugs*)	

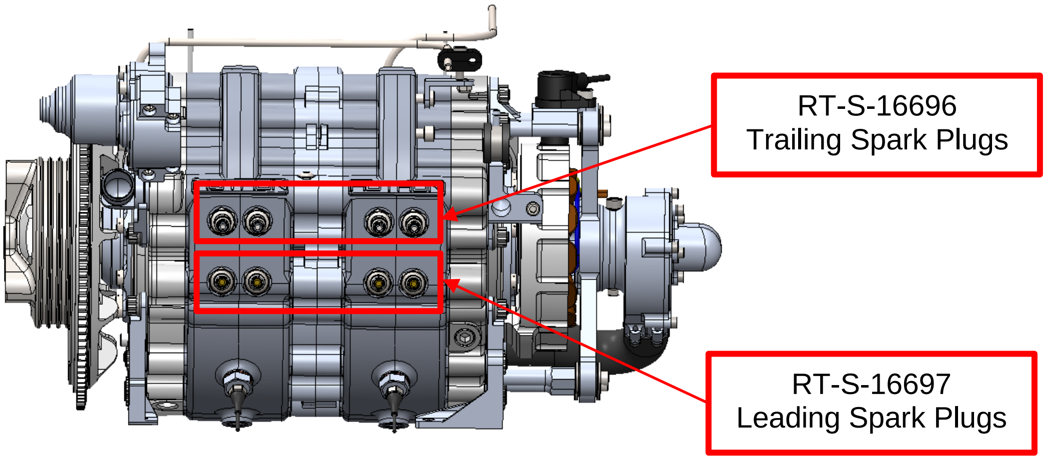


Figure 5-1 – Spark Plug Orientation.

5.2 APEX SPRING TRAVEL CHECK

The Apex Spring Travel (AST) check is important in order to ensure springs have sufficient load.

The steps detailed below will provide instructions on how to carry out the AST check. Results of the check should be recorded in Table 2-1 (Provided in Appendix 6) and transmitted to Rotron within the specified engine run time frame.

Note, this process can be undertaken within the aircraft.

1. Remove intakes and ensure there is good access to the intake ports (as in Figure 5-2).

Figure 5-2 – Comparable Engine with Intakes Removed.

2. Assemble AST jig as shown below.

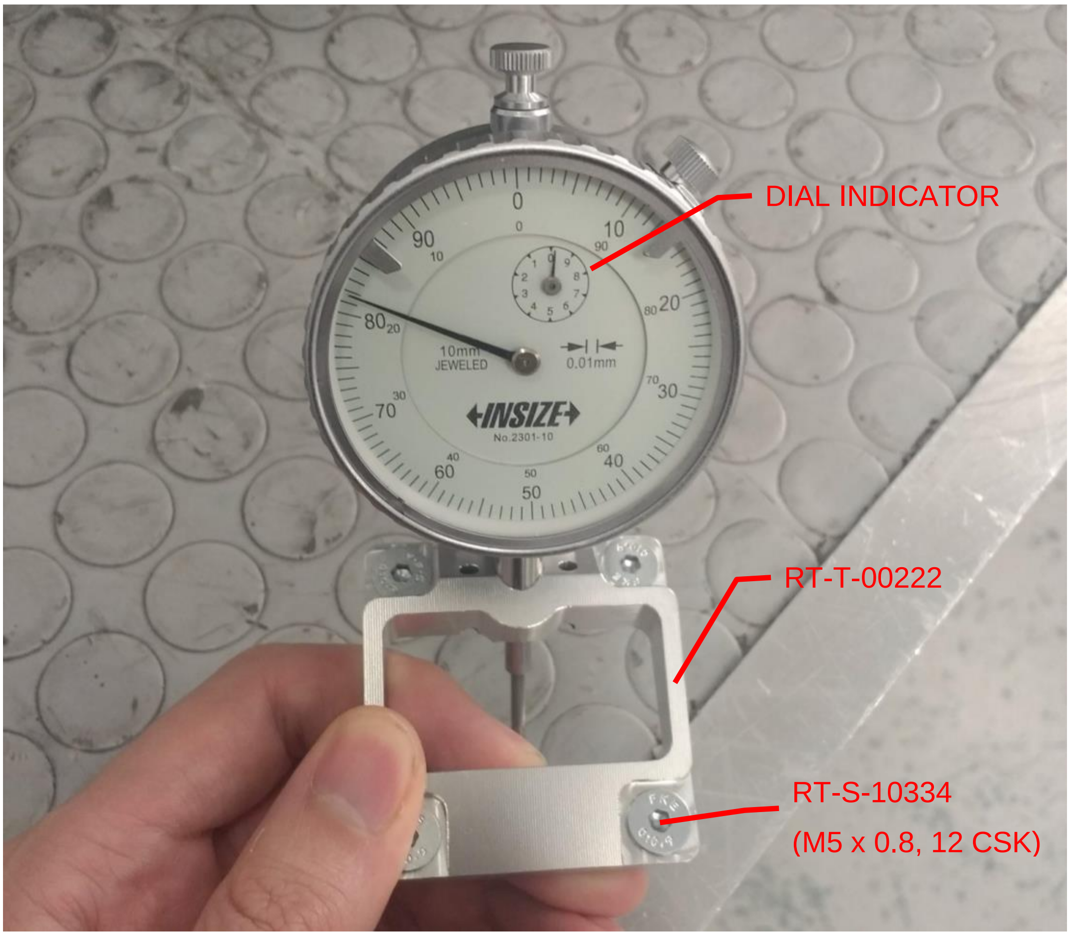


Figure 5-3 – AST Jig Ready for Assembling to the Engine.

3. Assemble AST jig to inlet.

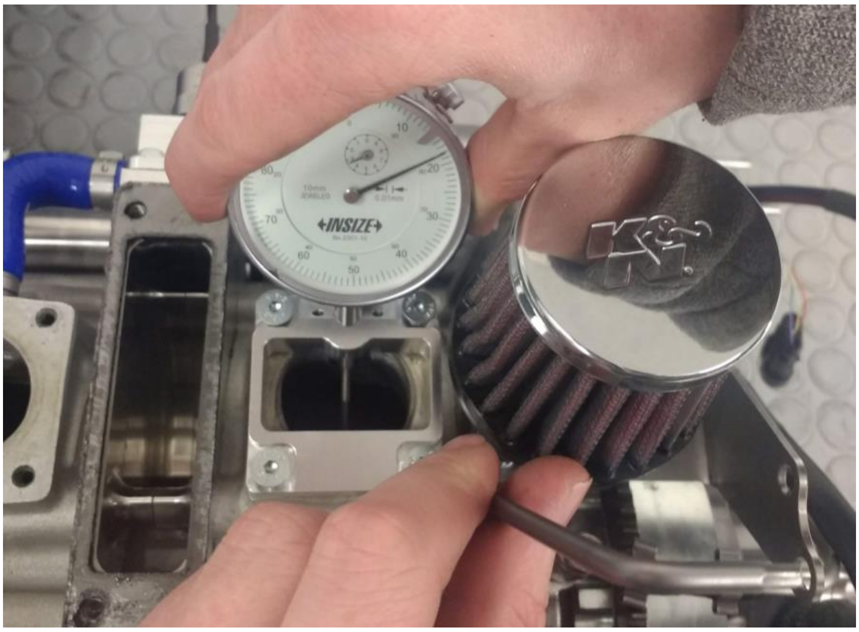


Figure 5-4 – AST Jig Assembled to Intake (Do Not Exceed Finger Tightness ~2 Nm).

4. Line up the dial indicator with the rotor at the highest point in its travel and zero the indicator.

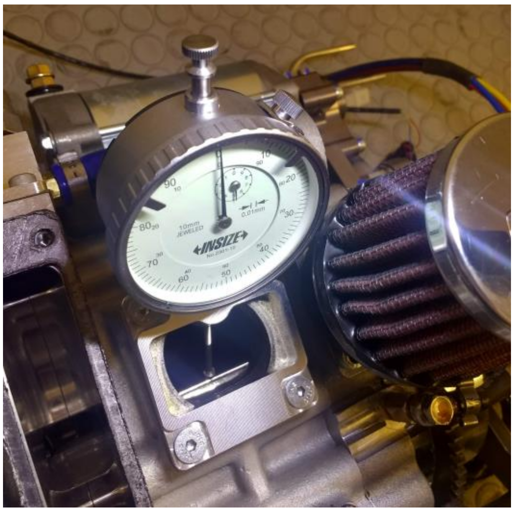


Figure 5-5 – Dial Indicator Lined Up and Calibrated to Zero, Ready for Measurement.

5. Press down on the apex seal until the spring is completely spring bound or bottomed out. Note the complete travel distance (in µm) in Table 2-1 (6 Appendix) & evaluate this value against the minimum limit.

Figure 5-6 – Push Down in the Direction Indicated Until the Spring is Fully Bottomed Out.

6. Lift the dial indicator to clear the rotor and rotate the balance wheel by hand until the next apex seal is lined up with the dial indicator. Repeat steps 3, 4, 5 & 6 for all apex seals on each rotor.

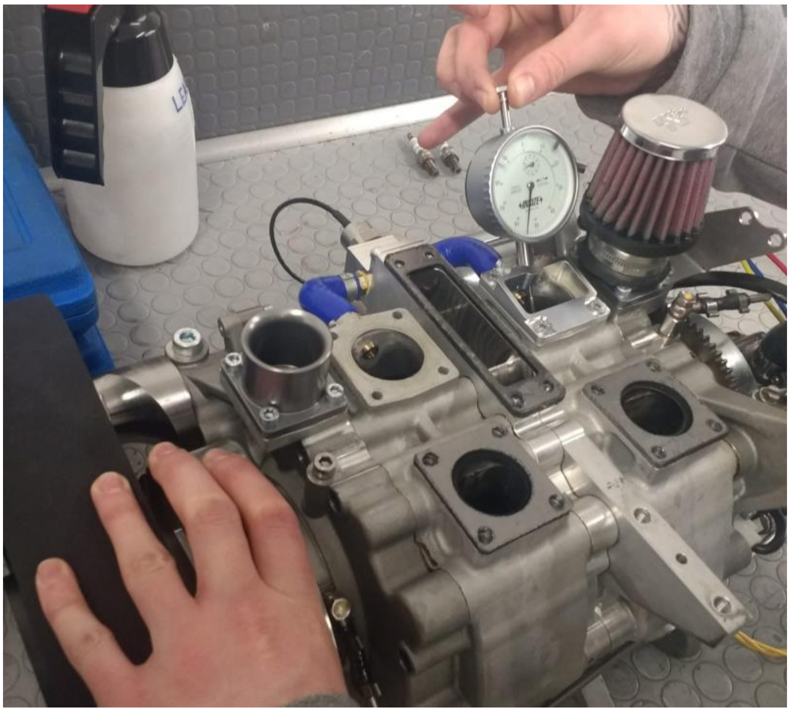


Figure 5-7 – Rotating to Next Apex Seal.

6 APPENDIX

Table 2-1 – Apex Spring Travel (AST) Check Bulletin Data Collection Table.

Engine Serial Number	

Date	**Total Engine Run Time**	**Check Performed by**	**Sent to Rotron**	**Signed**
<dd/mm/yyyy>	*<hh:mm>*	*<name>*	<√/X>	*<sign>*

Data collated in the table below must be correct to within ± 5 µm.

Engine Run Time (hh:mm)	**NDS Rotor AST (µm)** *Minimum Travel – 50 µm*			**DS Rotor AST (µm)** *Minimum Travel – 50 µm*		
	1	*2*	*3*	*1*	*2*	*3*
25						
50						
75						
100						

An update must be sent to Rotron Power ltd. in a timely fashion, (3 working days maximum) at every 10-hour flight time interval.