THE WALTER M 332 ENGINE – BRIEF HISTORY

The development of the supercharged 4-cylinder *Walter Minor 4-III Sc* and 6-cylinder *Walter Minor 6-III Sc* engines – later rebranded by *Motorlet* as M332 and M337, resp. - was started in early 1950's by the successor of the *Josef Walter a.s.* company which was founded in 1911. During the WWII and the post-war nationalization of industries in Czechoslovakia the company's name was changed many times – to *Walter Automobil und Flugmotoren Fabrik A.G.* (1939), *Letecké Závody n. p.* (1946), *Závody Jana Švermy* (1948), *Motorlet Praha* (1949), *Walter a.s. (1995), Walter Aircraft Engines* (2008), and *General Electric Aviation Cz* (2008). The 2001/2002 *P&WC* takeover agreement was never concluded. In 1964 all piston engine productions were transferred from *Motorlet* to *Avia Praha*, and in 1989 the production and development of piston engines and aircraft propellers were transferred back from *Avia* to a *Motorlet* division, *LOM*, in Prague-Malesice (LOM = acronym for *Aviation Overhauls, Malesice*).

However, throughout all those name changes the engine manufacturer always continued to use its original world-renowned registered trademark "Walter" for its engines. The production of the M332/337 engines ended in 1964, and the total number of all Walter piston engines produced between 1923 and 1964 is 16,930 of 44 different types, including 1,323 M332 and 2,737 M337 engines.

The *LOM Praha* predecessor was founded on Oct. 5, 1915, as an aircraft engine division of the Breitfeld-Daněk company. The engines were produced under the trade mark *Praga* and their technical parameters and quality level successfully competed with the best English and French engines.

During and after the WWII the company specialized in overhauls of German Jumo 211, Argus 410 and 411 engines used in Me-109, Arado and Siebel aircraft, as well as Merlin and Continental engines.

In the 1950's *LOM* added to its portfolio overhauls of the Walter Minor 4-III and 6-III, M-208B and Praga-D piston engines, as well as overhauls of the Motorlet M701 engines (L-29 Delfin jet trainer) and Russian RD-45 and VK-1 engines (MiG-19 and MiG-21 jet fighters).

In 1989 the newly independent state-owned *LOM Praha* restarted the development and production of inverted in-line engines with the M332A model which was certified in Nov. 1992.

M 332A - new-production M332 engine with a strengthened crankcase and improved camshaft housing seals

M 332AK - new oil system for unlimited-time inverted flights. Certified in Oct. 1994

M 332B - increased max. power (140 to 160 HP) through increased RPM (2700 to 3000);
- increased operating time limits of the supercharger;
- hollow crankshaft front end for use of hydraulic constant speed props;
- oil pump delivery capacity increased by 1/3 for control of the constant speed props;
- fully automatic fuel injection pump with altitude corrections for fuel delivery;
- TBO based on the type of oil used and type of operation:

Operation:	Normal	Aerobatic
Mineral Oils	1000	750 flt hrs
Ashless Dispersant (AD) Oils	2000	1400 flt hrs

M 332C - new piston design and compression ratio increased from 1 : 6,3 to 1 : 7,4;
- increased max power from 140 HP @ 2700 RPM to 168 HP @ 3000 RPM
- use of auto gas (BA 95N and BA 98N). Certified in 2001/2002

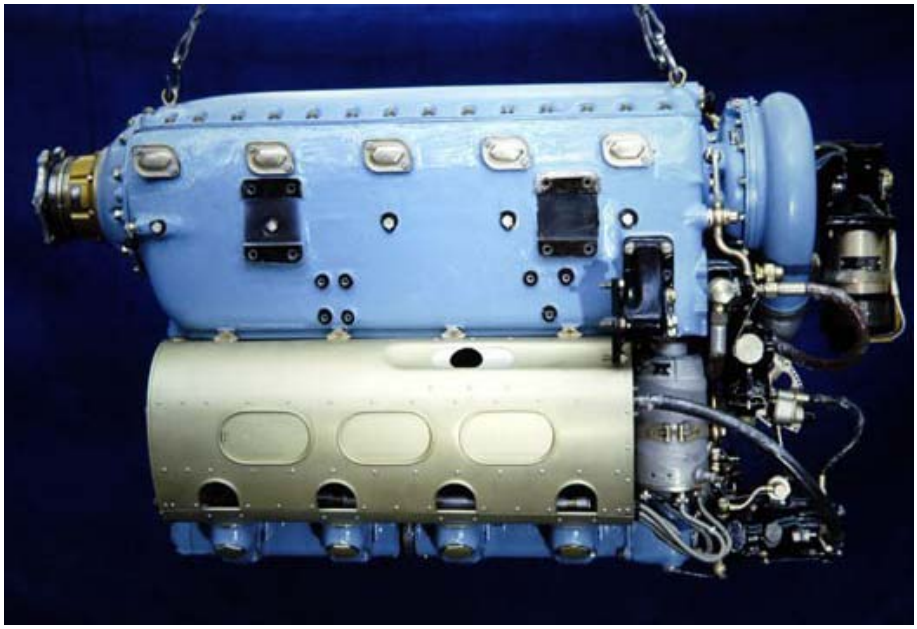
Planned developments (2003):
- gear box for 4 and 6 cylinder engines
- propeller speed governor for the LOM propulsion unit (i.e. engine + propeller)
- turbo-blower application on LOM engines
- development of a new type multi-cylinder engine

LOM Praha: Four- and six-cylinder in-line inverted air-cooled piston engines

Engine	No of cylinders	Super charger	Take-off Power (kW/HP)	RPM (1/min)	Measured Fuel Consumption in Cruise (gr/kW/hour)	Dry Weight (kg)	Specific Weight (kg/kW)	Manifold Pressure (kPa)
M 132A	4	No	90/122	2700	280	105,0	1,17	98
M 132AK	4	No	90/122	2700	280	105,0	1,17	98
M 332A	**4**	**Yes**	**103/140**	**2700**	**278**	**113,0**	**1,10**	**118**
M 332AK	**4**	**Yes**	**103/140**	**2700**	**278**	**113,0**	**1,10**	**118**
M 332B	4	Yes	118/160	3000	278	113,0	0,96	118
M 332C	**4**	**Yes**	**124/168**	**3000**	**265**	**113,0**	**0,91**	**122**
M 137A	6	No	132/180	2750	299	146,5	1,10	100
M 137AZ	6	No	132/180	2750	299	146,5	1,10	100
M 337AK	6	Yes	154/210	2750	292	153,0	0,99	118
M 337A	6	Yes	154/210	2750	292	153,0	0,99	118
M 337AK1	6	Yes	154/210	2750	292	153,0	0,99	118
M 337B	6	Yes	173/235	3000	278	153,0	0,88	118
M 337C	6	Yes	185/252	3000	387	153,0	0,82	122

List of Avia propellers recommended for engines M 132, M 137, M 332 & M 337

Propeller Type	No of Blades	Max Diameter (mm)	Dry weight (kg)	Max Power (kW)	Note
V 231	2	1800	13	160	Fixed, wood
V 341	2	2000	15,5-17 (without spinner) 19,5-20 (with spinner)	170	Metal, adjustable on the ground
V 500A	2	2000	25	162	Metal, hydraulically adjustable
V 546	3	2000	32-34	220	Metal, hydraulically adjustable
V 541	**2**	**2000**	**24-26**	**140**	**Metal, hydraulically adjustable**



M 332C with a hydraulically-controlled constant speed propeller hub

Table no.1
ENGINE RATING SPECIFICATIONS 1 kW = 1.341 HP

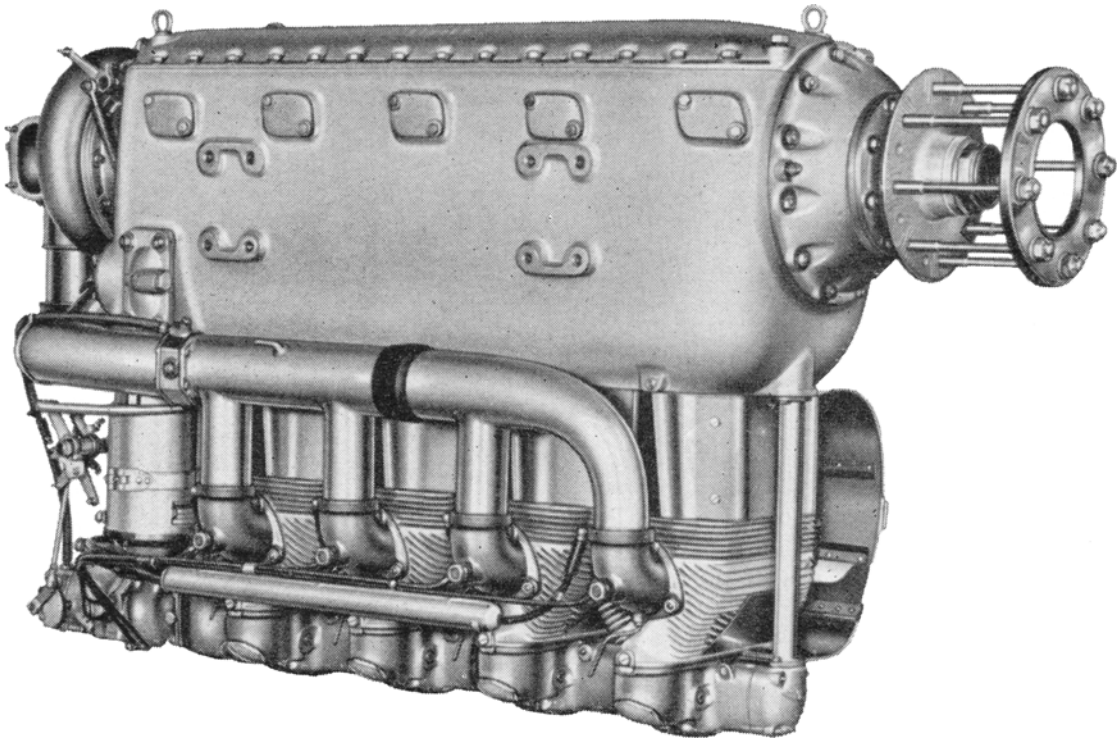
Rating	Compressor ON / OFF	RPM	Power Output [kW]±2.5%	Manifold pressure [MPa]±0.002	Fuel Cons. [g/kWxh]	Oil Cons. [g/kWx]
M 332, M 332A, M 332AK: The correction is set at lean mixture stop (-) at all ratings.						
Take-off	ON	2700±50[x]	103.0	0.118	$367^{+27}/_{-14}$	-
Nominal	OFF	2550±3%	84.6	0.100	$292^{+14}/_{-7}$	1.4-6.8
Cruise at S/L	OFF	2400+3%	73.5-5%	0.090	$278^{+14}/_{-7}$	-
Idle	OFF	500-600	-	-	-	-
M 137A, M 137AZ:						
Take-Off	N/A	2750+3%	132	0.1	$333^{+14}/_{-7}$	1
Nominal	N/A	2680±3%	118	0.0946	$313^{+14}/_{-7}$	1.35 max
Cruise	N/A	2580±3%	103	0.0874	299±7	0.6
% nominal 75%	N/A	2480±3%	88	0.0804 ±0.001	-	-
70%	N/A	2440±3%	82	0.078	-	-
65%	N/A	2390±3%	77	0.0755	-	-
60%	N/A	2340±3%	71	0.0721	-	-
55%	N/A	2230±3%	59	0.0667	-	-
Idle	N/A	500	-	-	-	-
M 337: The correction is set at -2 increments at all ratings.						
Take-off	ON	2750±50[x]	154	0.121-0.118	$367^{+27}/_{-14}$	-
Nominal	OFF	2600±3%	125	0.100±0.002	$292^{+14}/_{-7}$	1.4-11
Cruise at S/L	OFF	2400±3%	103	0.092+0.002	$278^{+14}/_{-7}$	1.4-8.2
Idle	OFF	500-600	-	-	-	-
M 337A, M 337AK:						
Take-off	ON	2750±50[x]	154	0.121-0.118	$388^{+27}/_{-14}$	-
Nominal	OFF	2600±3%	125	0.100±0.002	313±14	1.4-11
Cruise at S/L	OFF	2400±3%	103	0.092+0.002	292±7	1.4-8.2
Idle	OFF	500-600	-	-	-	-

[x] Tolerances when using a flight propeller: ±30 RPM

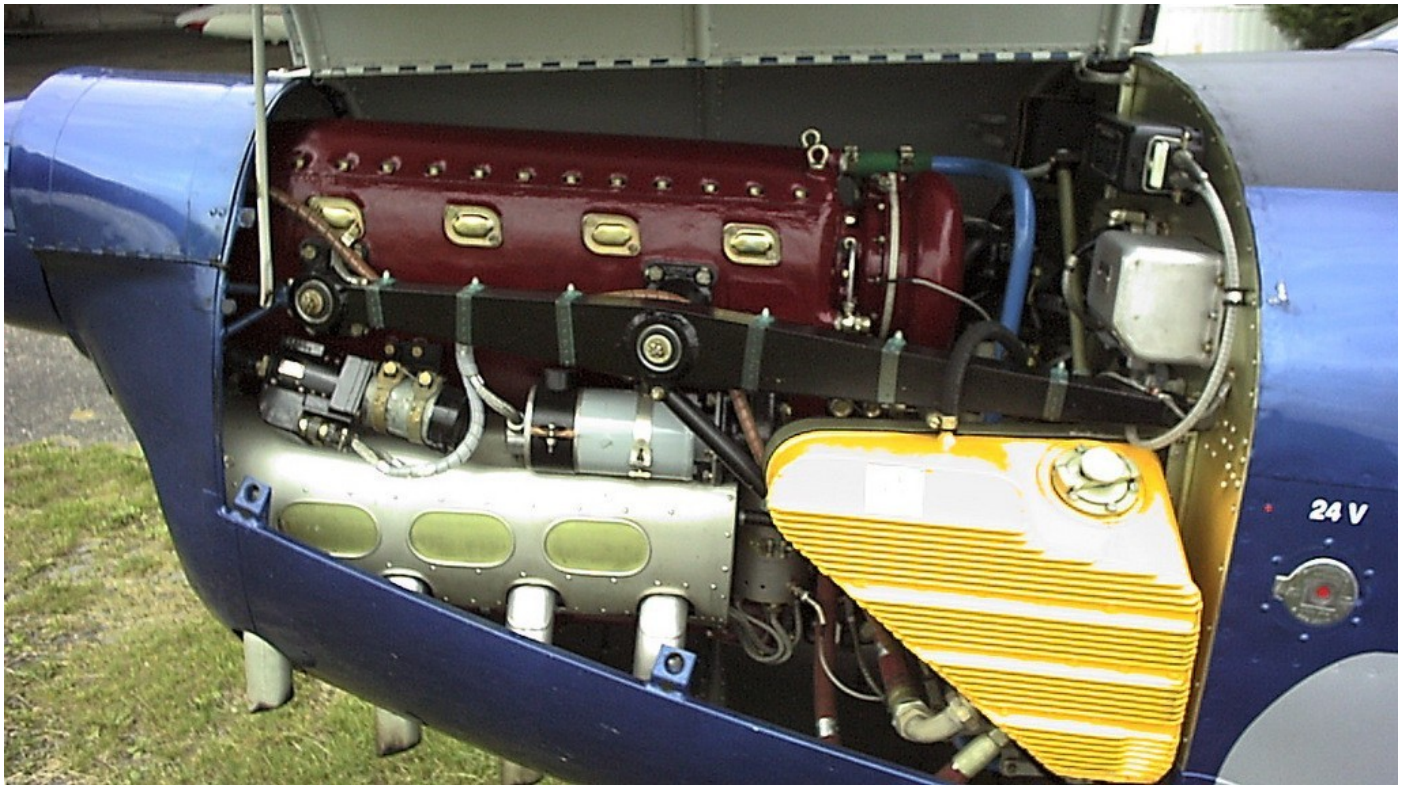
M 100 Series = Carbureted engines, without a supercharger
M 300 Series = Fuel-injected supercharged engines

M 332.. Models = 4-Cylinder engines
M 337.. Models = 6-Cylinder engines

M ...A Suffix = New-production engines (since 1992)
M ...AK Suffix = Oil system for unlimited-time inverted fights



M332



PART I. DESCRIPTION OF THE ENGINE.(*)

Technical specifications

M 332 aero engine is an internal combustion four-stroke air cooled four cylinder inverted engine with low-pressure fuel priming before inlet valves and with a disengageable supercharger. The propeller is fitted directly on the front end of the crankshaft.

Production mark	M 332 (*)
Direction of rotation of crankshaft and propeller	Anti-clockwise

Cylinders

Number and disposition of cylinders	4, inverted in one row
Bore	105 mm
Stroke	115 mm
Piston displacement	0,995 lit.
Total stroke volume of engine	3,98 lit.
Compression ratio	6,3 : 1

Output and speed

	Rating in BHP	Revolutions p.m.
Take-off power of the engine limited to 5 minutes	140	2700
Rated /climbing/ power for an unlimited period of time	115	2550
Maximum cruising power for an unlimited period of time	maximum 100	2400
Cruising power in an altitude of 1000 to 2000 m	100 – 80	2400 - 2300
Specific output at take-off power	35,1 BHP/lit.	

Fuel and oil and consumption

Values stated here are the average consumptions, when prescribed fuel and oil are used.

Fuel prescribed	Aviation petrol non-ethylised with minimum 72 octane number satisfying the prescription fuels, of specific weight 0,720 - 0,730, with the beginning of evaporation at 37.5°C.
Oil prescribed	Best mineral oil of specific weight maximum 0,92 satisfying the conditions for aviation lubricants of absolute kinetic viscosity 17 - 24 E at 50°C.

(*) Data apply to the M 332 (Walter Minor 4-III Sc) engine as used on the L-40

Grease	Normal ball bearing grease for lubricating the lever reduction gear.
Fuel consumption at take-off output	260 g/BHP/hour
Fuel consumption at rated sea level output	215 ± 5 g/BHP/hour
Fuel consumption at cruising sea level output	205 ± 5 g/BHP/hour
Fuel consumption at cruising output in an altitude of 1000 - 2000 m	195 ± 5 g/BHP/hour
Oil consumption at rated sea level output	1 - 5 g/BHP/hour
Fuel consumption per hour at rated sea level output	25 kg, i.e. 34 lit.
Oil consumption per hour at rated sea level output	maximum 0,3 kg, i.e. about 0.4 Lit.
Total fuel and oil consumption per hour at rated sea level output	25,5 kg

Valve timing and its adjustment

The following figures are theoretical mean values. The actual measured values for the first cylinder are indicated on the data plate of every engine.

Number of valves in the cylinder	2; 1 inlet and 1 exhaust valve
Arrangement of the valves	Inclined under the angle of 56°
Valve operating mechanism	From the camshaft placed in the camshaft box on the cylinder heads, by means of rockers
Theoretical valve timing at the clearance on cam	0,2 mm
Inlet valve opens	25° before T.D.C.
Inlet valve closes	65° after B.D.C.
Total opening of inlet valve	270°
Exhaust valve opens	65° before B.D.C.
Exhaust valve closes	25° after T.D.C.
Total opening of exhaust valve	270°
Cold clearance of inlet valves	0,25 mm
Cold clearance of exhaust valves	0,40 mm

Induction system

Priming pump	Yc, with automatic regulation, altitude correction and delivery fuel pump
Gear ratio to priming pump	2:1
Fuel nozzles	4; one for each cylinder, in the space before the inlet valve
Fuel pressure in fuel nozzle	3,5 atm.
Normal fuel pressure behind delivery fuel pump	0,2 - 0,3 atm.

Minimum fuel pressure behind delivery fuel pump	0,1 atm.
Boost pressure in induction manifold at take-off power	1,19 atm. abs
Boost pressure in induction manifold at rated power	1,00 atm. abs.
Boost pressure in induction manifold at cruising power maximum	0,90 atm. abs.
Compressor	Radial with disengageable planetary gear
Compressor drive	From the rear end of the crankshaft through the elastic coupling
Gear ratio to compressor impeller with engaged planetary gear	1 : 7,4
Gear ratio to compressor impeller with disengaged planetary gear	1 : 1; planetary gear acting as coupling

Ignition

Number of magnetos on the engine	2
Magnetos	Scintilla Vertex OBF 4 R 502 Z 170 screened
Magneto speed ratio	2 : 1
Direction of rotation of magnetos /when looking at their shaft/	Clockwise
Ignition point adjustment	Automatic
Maximum ignition advance /measured on the crankshaft/	32° B.T.D.C. at the right magneto 35° B.T.D.C. at the left magneto
Range of the automatic ignition point adjustment /measured on the magneto shaft/	12,5°
The automatic adjustment of the ignition point begins to act at approx.	1000 R.P.M. of the engine
Maximum ignition advance is reached at approx.	1500 R.P.M. of the engine
Contact-distance of magneto interrupters	0,3 – 0,4 mm
Firing order /according to cylinder numbers/	1 - 3 - 4 - 2
Number of spark plugs in one cylinder	2
Spark plugs	Screened PAL L 22.62
Spark plugs thread	M 12 x 1,25
Thread for connecting of screening elbow	M 14 x 1
Electrode gap	minimum 0,4 mm
Starting buzzer engaged	on the right magneto

Lubrication

System of lubrication	Force-feed lubrication system with dry crankcase
Number of oil pumps	2
Main oil pump	No. 1 double gear type pump, with one pressure and one scavenge pump
Pump speed ratio	2:1
Output ratio of the pressure and the scavenge pumps	2:3
Auxiliary scavenge oil pump No. 2	Gear type pump, which sucks off the oil from the space of camshaft boxes
Pump speed ratio	1 : 1
Mean oil flow through the engine at nominal revolutions	120 kg/hour, i.e. about 130 lit.
Minimum amount of oil in the tank necessary for the circulation	About 5 lit.
Normal oil pressure	3,5 - 4 atm.
Minimum emergency oil pressure	2,5 atm.
Intake oil temperature:	
- minimum, for engine test	30°C
- normal	40 - 80°C
- maximum	85°C
Outlet oil temperature:	
- minimum, for engine test	35°C
- normal	50° - 90°C
- maximum	100°C /for a short period of 5 min/

Cooling

Cooling of the cylinders	By air
Air inlet orifice area in engine cowling	250 cm^2
Air outlet orifice area of the cooling air	about 500 cm^2
Pressure drop of the air stream between the inlet and the space inside the cowling behind the engine	160 mm of water column
Normal temperature of cylinder heads /measured under the spark plugs on the right side of the engine/	150° - 170°C
Maximum temperature of cylinder heads at the take-off for a time of 5 minutes and surrounding air temperature of +20°C	190°C
Cooling air maximum temperature	35°C

Starting

Starter	Electric, with worm gear, located on the rear flange of the compressor casing
Starter jaw	When starting it engages in the jaw of the impeller shaft of the engaged compressor
Disengagement of the jaw	By electric solenoid
Electromotor output	1,2 HP
Total electromotor gear ratio to crankshaft	120 : 1
Priming pump	Automatically set to the correct mixture, which can be enriched by a hand-lever
Starting buzzer	Mounted into the right magneto circuit to strengthen the initial spark

Drives and accessories

Propeller regulator drive for a variable pitch propeller	By a dog of the right drive lay-shaft
Direction of rotation of the regulator drive	Clockwise
Regulator drive speed ratio	2 : 1
Tachometer drive	According to ČSN AE 5,15
Direction of rotation of the tachometer drive	Clockwise
Tachometer drive speed ratio	2 : 1
Tachometer generator drive	By gearing on the right-hand side of the crankcase
Tachometer generator drive speed ratio	1 : 1
Direction of rotation of the tachometer generator drive	Clockwise
Generator	Scintilla /left-hand rotating/ 300 or 600W, 28V, 4000-7000 RPM.
Generator drive	By gearing on the left-hand side of the crankcase
Gear ratio to the generator drive	1 : 1,785
Direction of rotation of the generator drive	Anti-clockwise

Weights

Dry weight of the engine with: magnetos and screened ignition system, priming pump, air scoop and air baffles, exhaust pipes, compressor and electric starter	102 kg ± 2%

According to the engine equipment the following weights should be added:

Weight of the propeller hub with retaining nut for wooden propeller	2,40 kg
Weight of four normal bearing feet and rubber dampers:	
- with longer dampers	1,00 kg
- with shorter dampers	0,75 kg
Weight of the electric starter	3,95 kg
Weight of tachometer generator drive	0,27 kg
Weight of generator drive	0,73 kg
Weight of generator 300 W	3,90 kg
Weight of generator 600 W	5,05 kg
Weight of the remaining oil in the engine	kg
Specific weight of the engine at sea level take-off power and mentioned dry weight of the engine	0,7 kg/BHP

Engine dimensions.

Length of the engine with starter without propeller hub	1102 mm
Engine width without bearing feet	425 mm
Overall height of the engine	628 mm
Height of the engine above the propeller axis	143 mm
Height of the engine under the propeller axis	485 mm

Dimensions of pipe lines.

Fuel supply pipe line	6 mm I.D.
Fuel drain pipe from induction manifold	5 mm O.D./3 mm I.D.
Pipe line to fuel pressure gauge	4 mm I.D.
Oil supply pipe line	20 mm I.D.
Oil return pipe line	10 mm I.D. minimum
Pipe line to oil pressure gauge	4 mm I.D.
Air pipe line to boost air pressure gauge	4 mm I.D.

Engine transport box dimensions.

Length of a normal transport box	1352 mm
Width of a normal transport box	636 mm
Height of a normal transport box	870 mm
Weight of a normal transport box	90 kg
Total weight of the box together with the engine and accessories	204 kg

There is a type plate on every engine on the right side of the crankcase cover with the engine serial number. There is another plate underneath stating the principal data, information about the valve and ignition timing, operation of the engine, fuel and lubricants, their consumptions, temperatures and pressures.

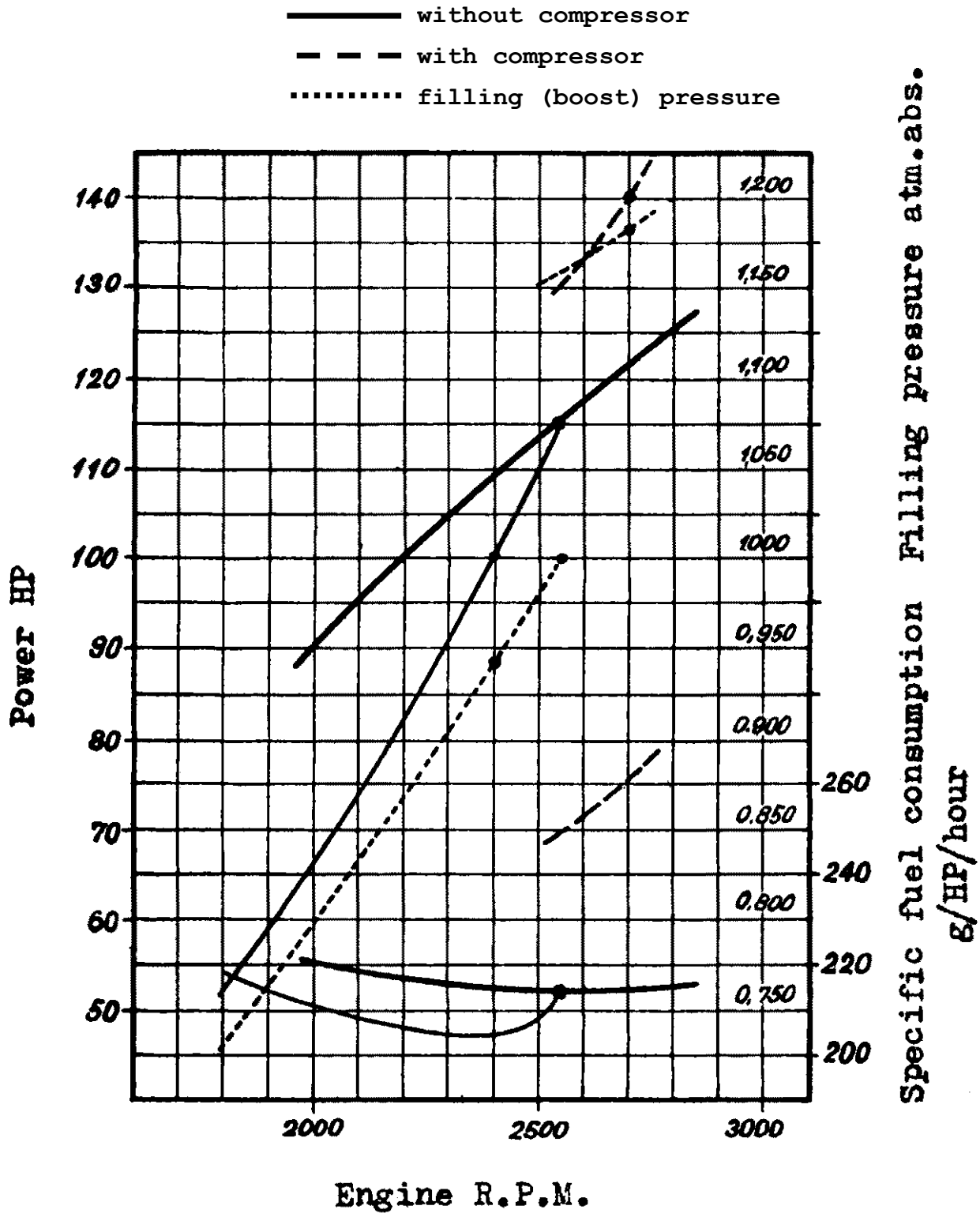


Fig. 5. Power, filling (boost) pressure and specific consumption curves.

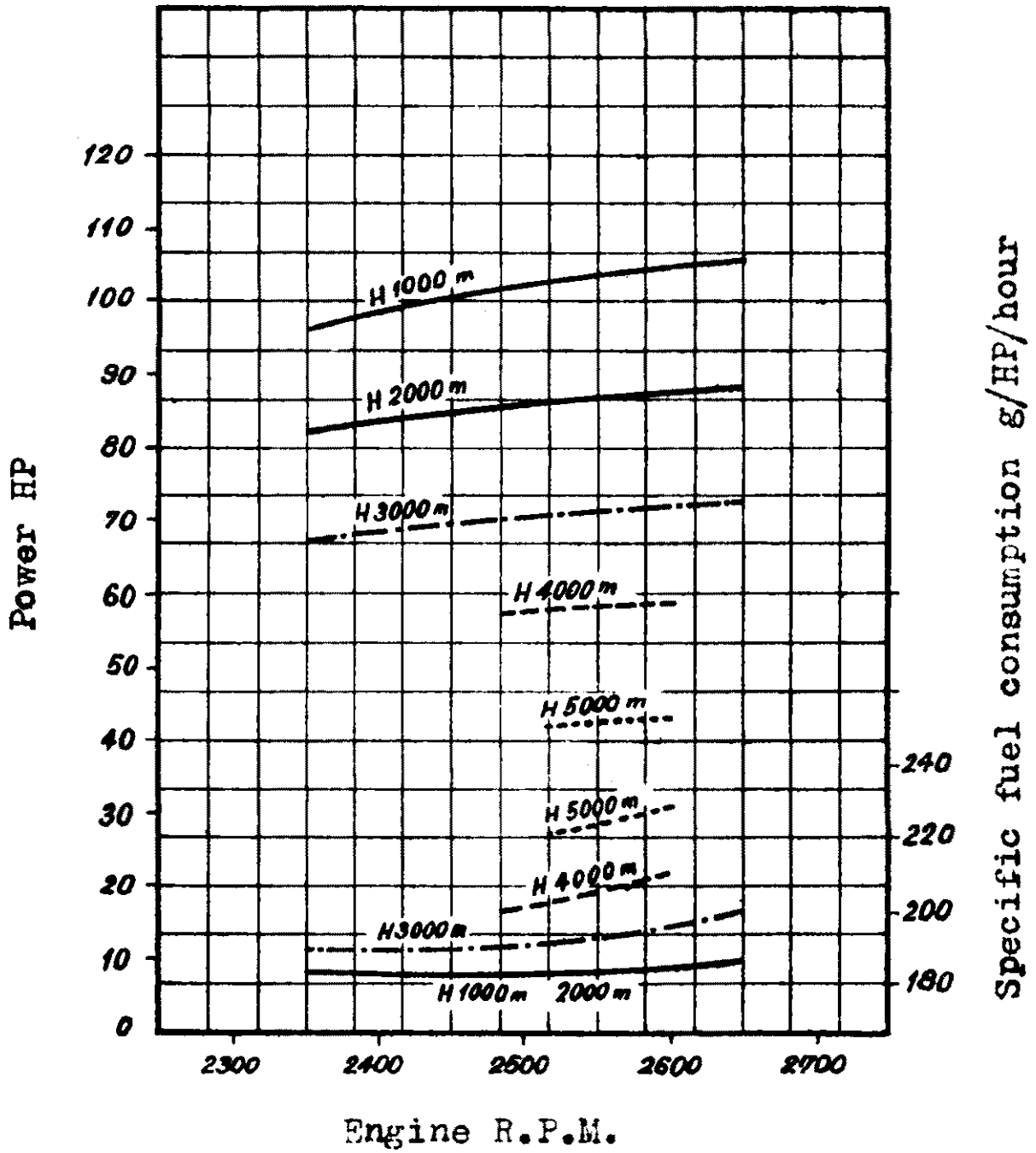


Fig. 6. Power and specific consumption curves in altitudes with disengaged compressor