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Standard British method of performance reduction for piston-engined aircraft with constant-speed propellers

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THE PREPARATION OF THIS DATA ITEM

The work of the Engineering Sciences Data Unit on this series is monitored and guided by Technical Committees of the Royal Aeronautical Society. The Committee responsible for this particular Data Item was the Performance Committee, which first met in 1946, and has the following constitution:

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The members of staff of the Royal Aeronautical Society associated with the Performance Committee were Miss E.C. Pike and the Technical Secretary of the Society, Dr D.M.A. Leggett.

STANDARD BRITISH METHOD OF PERFORMANCE REDUCTION FOR PISTON-ENGINED AIRCRAFT WITH CONSTANT-SPEED PROPELLERS

1. NOTATION AND UNITS

A	aspect ratio $= b^2/S$	–
B	absolute boost pressure	lbf/in^2
b	aircraft span	ft
C	supercharger constant, defining the variation of supercharger pressure ratio with temperature	–
c	cylinder compression ratio	–
C_D	total drag coefficient	–
C_{DZ}	a constant in Equation (3.2)	–
C_P	propeller power coefficient	–
D_{100}	the part of the drag at 100 ft/s at sea level corresponding to C_{DZ} ($=11.88SC_{DZ}$)	lbf
J	propeller advance ratio	–
K	constant defined by Equation (3.2), sometimes called “the induced drag factor”	–
P	power supplied to propellers	hp
P_F	friction power at zero density	hp
p	static air pressure	lbf/in^2
Q	fuel flow	gal/hr
r	supercharger pressure ratio	–
r_0	value of r at 15°C	–
S	wing area	ft^2
T	air temperature	K
V	true airspeed	knot
V_i	equivalent airspeed $= V\sqrt{\sigma}$	knot

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$(V_i)_{md}$	equivalent airspeed for minimum drag defined by Equation (2.1)	knot
v_c	true rate of climb	ft/min
W	aircraft weight	lbf
ΔB	correction to boost pressure $= -(B_a - B_s)$	lbf/in^2
ΔT	$T_a - T_s$	K or °C
η	propeller efficiency	–
ρ	air density	slug/ft^3
σ	relative density, ρ/ρ_0	–

Subscripts

a	denotes ambient or test conditions
s	denotes value in International Standard Atmosphere
0	denotes value at sea level in International Standard Atmosphere (ESDU 68046, Reference 1, gives numerical values)

2. INTRODUCTION

Data Items in the group ESDU PERF RP 1/1, 1/2 and 1/3 (References 2, 3 and 4) give the standard British methods of performance reduction for piston-engined aircraft with constant-speed propellers. Besides ignoring compressibility effects these methods contain certain other assumptions, for example average values are assumed for the variation of propeller efficiency with speed and for the effect of forward facing intakes and the relations assumed for the engine performance do not apply to turbo-blown or compounded engines, or to engines with charge temperature control. Because of these limitations there are some cases in which it is necessary to use a more general form of the performance reduction equation, and ESDU PERF RP 2/0 (Reference 5) suggests a method of doing this.

The formulae given in Data Items of the group ESDU PERF RP 1/1 to 1/3 enable corrections to be made for temperature differences from standard, for change of weight, and for the effect of wind gradient on rate of climb.

It will be noticed that the notation used is slightly different from that of Reference 6; in particular the minimum drag speed, $(V_i)_{md}$, has been used instead of the minimum power speed, $(V_i)_{mp}$.

It can be shown from Tables 5.1 and 5.2 of ESDU 81026 (Reference 7) that

$$(V_i)_{md} = 23.97 D_{100}^{-1/4} \left((W/b) \sqrt{K} \right)^{1/2} \tag{2.1}$$

and it is worth noting that this quantity need be calculated once only for a particular aircraft at a given weight.