



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

Endorsed by
The Royal Aeronautical Society

ESDU DATA ITEMS

Data Items provide validated information in engineering design and analysis for use by, or under the supervision of, professionally qualified engineers. The data are founded on an evaluation of all the relevant information, both published and unpublished, and are invariably supported by original work of ESDU staff engineers or consultants. The whole process is subject to independent review for which crucial support is provided by industrial companies, government research laboratories, universities and others from around the world through the participation of some of their leading experts on ESDU Technical Committees. This process ensures that the results of much valuable work (theoretical, experimental and operational), which may not be widely available or in a readily usable form, can be communicated concisely and accurately to the engineering community.

We are constantly striving to develop new work and review data already issued. Any comments arising out of your use of our data, or any suggestions for new topics or information that might lead to improvements, will help us to provide a better service.

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:

Chairman
Mr H. Davies

Members
Mr W.J. Annand
Mr S.R. Hughes
Mr K.J. Lush
Mr D.R. Newman
Mr R.H. Whitby
Mr A.H. Yates

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-ENGINEED AIRCRAFT WITH CONSTANT-SPEED PROPELLERS. FUEL CONSUMPTION

1. NOTATION AND UNITS

B	absolute boost pressure	lbf/in ²
C	supercharger constant defining the variation of supercharger pressure ratio with temperature (see ESDU PERF RP 1/0, Reference 1)	—
N	engine speed	rpm
Q	fuel consumption	gal/hr
R	specific air range	n.mile/gal
T	air temperature	K
t	air temperature	°C
V	true airspeed	knot
V_i	equivalent airspeed = $V\sqrt{\sigma}$	knot
$(V_i)_{md}$	equivalent airspeed for minimum drag	knot
ΔB	correction to $B = -(B_a - B_s)$	lbf/in ²
ΔQ	correction to $Q = -(Q_a - Q_s)$	gal/hr
ΔT	$T_a - T_s$	K or °C
ΔV_i	correction to $V_i = -((V_i)_a - (V_i)_s)$	knot
ρ	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 2, gives numerical values)

Issued October 1950 – 4 pages
With Amendment A, March 2009 – 8 pages
This page Amendment A

2. NOTES

This Data Item gives formulae, which correspond to the agreed British methods contained in Reference 3, for the correction to standard conditions of observed[†] fuel flow measurements for piston-engined aircraft with constant-speed propellers. This Data Item also shows the method of deducing specific air range and gives examples of typical range and endurance results.

If the range of weights at which the aircraft will fly is large, attention should first be directed to the behaviour of the aircraft at light weight, since at this weight it will be possible to obtain the greatest range of engine conditions; if the useful weight range is small, a single representative weight can usually be selected, to correspond as closely as possible to the mean weight to be used in operation.

Fuel consumption tests may be made in two ways; either by taking readings over a complete range of rpm and boost at any height, or by taking readings on the “envelope”. “Envelope” conditions are those for maximum nautical miles per gallon at a given airspeed, and at any speed they are generally obtained at the lowest rpm at which that speed can be maintained at the highest available or permissible boost in weak mixture.

3. TESTS FOR A COMPLETE RANGE OF RPM AND BOOST

When a complete range of rpm and boost has been covered, the results may be reduced either at constant rpm and boost or at constant rpm and V_i . Correction at constant rpm and boost is the more usual, and is the method given in this Data Item. The observed values of V_i are corrected for weight and air temperature by using Equations (3.1) and (4.2) and Figures 1 and 2 of ESDU PERF RP 1/1, (Reference 5). The observed fuel flow is corrected by using Equation (5.2) of the present Data Item. The corrected results are usually plotted as V_i against N and B , and as Q against N and B . The “carpet” method of plotting (Reference 6) is an advantage, and Figures 1 to 4 show both methods. The specific air range R ($= V/Q$) at any value of N and B is obtained by dividing V_i by Q and by the standard value of $\sqrt{\sigma}$ at the particular height, and is usually plotted against V_i as in Figure 5.

4. TESTS FOR “ENVELOPE” CONDITIONS

When “envelope” conditions have been measured, they can be reduced to standard conditions only by correcting V_i , fuel flow, and boost, since the results are partly throttled and partly full-throttle and they must, after correction, apply to the maximum permissible or maximum obtainable boost at each rpm. The observed V_i is corrected for weight and air temperature by using Equations (3.1) and (4.2) of ESDU PERF RP 1/1 (Reference 5) for throttled conditions and Equations (3.1) and (5.1) of that same Data Item for full-throttle results. The fuel flow is corrected by using either Equation (5.1) or (5.2) of the present Data Item, whichever is applicable. The boost correction, as given in ESDU PERF RP 1/0 (Reference 1), is

$$\Delta B = 0.002 \text{ (or } 0.001, 0.003) B \Delta T$$

at full throttle and zero under throttled conditions. The results are usually plotted as R against V_i and as Q against V_i with the corrected boost and rpm marked against each point. A typical fuel consumption “envelope” is shown in Example 7.2.

[†] The use of the term “observed” implies here that the appropriate corrections have been applied to the instrument readings (see ESDU 86031, Reference 4).