

ESDU Flaps 02.01.06

PROFILE DRAG COEFFICIENT INCREMENT DUE TO FULL-SPAN SINGLE-SLOTTED FLAPS (HANDLEY PAGE AND NACA TYPES)

1. NOTATION AND UNITS

		SI	British
c	wing chord	m	ft
c'	extended wing chord (see sketch on Figure 1)	m	ft
c_f	flap chord	m	ft
δ_f	flap angle	degree	degree
$\Lambda_{1/4}$	sweepback angle of wing $1/4$ -chord line	degree	degree
ΔC_{D0}	profile drag coefficient increment		
<i>Suffix</i>			
$\Lambda_{1/4}$	relating to swept wing		

2. NOTES*

The profile drag coefficient increment, ΔC_{D0} , due to full-span single-slotted flaps of the Handley Page and NACA types is plotted in Figure 1 against flap angle, δ_f , for various ratios of flap chord/wing chord, c_f/c (with $c'/c \leq 1.12$). The flap angle refers to the deflection of the flaps from the neutral position.

The data, from Derivation 1, refer to rectangular wings of aspect ratio 6 at an angle of incidence of 6 degrees above the zero-lift angle. The curves will be approximately correct at other angles of incidence provided that the stall is not too closely approached. The effect of aspect ratio different from 6 can be assumed negligible.

The effects of the thickness/chord ratio of the wing and the position of the flap hinge on the profile drag increment are of minor importance and have been neglected. The available evidence on the effect of Reynolds number is scanty but does not indicate that it is appreciable.

* Item No. 87005 provides data for the drag coefficient increment due to the deflection of single-slotted flaps on aerofoils at zero incidence. It covers large chord extensions and more modern sections than those current at the time Item No. Aero F.02.01.06 was developed. It is tentatively suggested that the data in Item No. 87005 may be applied to unswept untwisted wings of aspect ratio greater than 6 with full-span flaps. The data are not considered to be applicable to swept wings.

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Limited data on the effects of wing sweep indicate the following approximate relation (Derivation 2)

$$(\Delta C_{D0})_{\Lambda_{1/4}} = (\Delta C_{D0})_{\Lambda_{1/4} = 0} \cos \Lambda_{1/4}. \quad (2.1)$$

For part-span slotted flaps or for the effect of wing taper, Data Item No. F.02.01.07 may be used. For the additional effect of flaps on the induced drag, see Data Item No. F.02.01.08.

Note that the profile drag increments as given in this sheet are applicable to wings alone. For information on the effect of wing-body interference on profile drag increments, see Item No. 97003.

3. DERIVATION

1. YOUNG, A.D.
HUFTON, P.A. Note on the lift and profile drag effects of split and slotted flaps. RAE Report BA 1707, ARC Report 5472, 1941.
2. YOUNG, A.D. The aerodynamic characteristics of flaps. ARC R & M 2622, 1947.

4. EXAMPLE

Find the profile drag coefficient of a rectangular wing with a full-span single-slotted NACA flap at a flap angle of 45 degrees. The flap chord is $0.22c$ and the profile drag coefficient of the wing with the flap in the neutral position is 0.010.

From Figure 1 with $\delta_f = 45^\circ$ and $c_f/c = 0.22$

$$\Delta C_{D0} = 0.056.$$

The total profile drag coefficient for the wing is therefore $0.056 + 0.010 = 0.066$.