

ESDU Flaps 08.01.02

INCREMENT TO C_{m0} DUE TO FLAPS ON SWEPT-BACK WINGS

See Item No. 97002 for an introduction to Items on high-lift devices. This Item has been superseded by Item Nos 98009, 98017, 99004 and 99014. It has been retained in the Series because it is cross - referenced in other Items and because it allows treatment of a split flap with forward translation.

1. NOTATION AND UNITS

		SI	British
A	aspect ratio, b^2/S		
a_0	slope of lift curve for wing of infinite aspect ratio	rad^{-1}	rad^{-1}
a_6	slope of lift curve for unswept wing of aspect ratio 6	rad^{-1}	rad^{-1}
b	wing span	m	ft
b_f	flap span	m	ft
$(C_{m0})_\Lambda$	pitching moment coefficient of swept-back wing at zero lift based on $\bar{c}$ and S and referred to pitching axis passing through quarter-chord point of aerodynamic mean chord		
c	wing chord	m	ft
c_f	flap chord	m	ft
c_r	root chord	m	ft
c_t	tip chord	m	ft
$\bar{c}$	standard mean chord of wing with flap retracted, S/b	m	ft
c'	local extended or reduced chord, see sketch in Item No. Aero F.08.01.01	m	ft
K_Λ	conversion factor for part-span flap on swept-back wing		
S	gross wing area	m^2	ft^2
ΔC_{LF}	lift coefficient increment due to full-span flap on an unswept wing of aspect ratio 6, based on area of wing with flap retracted, see Item Nos 74009, Aero F.01.01.08 and 09		
ΔC_m	pitching moment coefficient increment due to part-span flap on same wing as that under consideration but with zero sweep, based on $\bar{c}$ and S and referred to quarter-chord line of wing, see Item No. Aero F.08.01.01		

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$\Delta(C_{m0})_{\Lambda}$	pitching moment coefficient increment at zero lift due to flap on swept-back wing		
Λ	angle of sweepback of quarter-chord line	deg	deg
λ	taper ratio, c_t/c_r		

2. NOTES

The change in pitching moment coefficient at zero lift due to the deflection of a flap on a swept-back wing is represented by

$$\Delta(C_{m0})_{\Lambda} = \Delta C_m + K_{\Lambda} (A/1.5)^* \Delta C_{LF} \tan \Lambda. \quad (2.1)$$

The first term on the right-hand side of Equation (2.1) represents the sum of the pitching moments about the local quarter-chord points, taken over the flapped part of the wing, and, for angles of sweep less than about 30°, this sum is assumed to be the same as that of the corresponding unswept wing. The second term arises from the change in spanwise lift distribution over the wing produced by the flap and the fact that, for a swept wing, this lift distribution has a net moment about the pitching moment datum – the pitching axis passing through the quarter-chord point of the aerodynamic mean chord.

It has been assumed that the section pitching moment coefficient increment, the lift increment due to the flap, and the spanwise lift distributions are identical for the swept and unswept wing. This in fact is not the case; the spanwise and chordwise lift distribution and the flap effectiveness vary with sweep. However, the effects of these changes on the pitching moment partially cancel each other for a part-span flap as they are of opposite sign. The overall accuracy of the data presented is therefore better than would be expected from the assumptions of the underlying theory.

In Equation (2.1), ΔC_m may be obtained from Item No. Aero F.08.01.01, ΔC_{LF} from Item Nos Aero F.01.01.08, F.01.01.09 and 74009, and K_{Λ} from Figures 1a to 1e of the present Item.

The data apply to split and slotted flaps on wings with an angle of sweepback of the quarter-chord line up to about 30°. Experimental evidence on the effect of flaps on wings with larger angles of sweep is scanty and is derived mainly from tests at low Reynolds number (0.3×10^6), but it indicates that, for part-span flaps only, the data may be used for angles of sweepback up to 45° with little further loss of accuracy.

For flaps which have their trailing edge forward of the trailing edge of the wing, as well as for flaps which extend the wing chord when deflected, the lift coefficient increment ΔC_{LF} may be obtained from the conversion formula given in Item No. Aero F.01.01.08, namely

$$\Delta C_{LF} = \Delta C'_L \left(\frac{c'}{c} \frac{a}{a_0} \right) + C_{LN} \left(\frac{c'}{c} - 1 \right). \quad (2.2)$$

It should be noted that wings having a considerable amount of sweepback tend to premature tip-stalling and the range of angles of incidence over which C_m is linear with incidence is then considerably reduced in comparison with the unswept wing.

* The figure 1.5 has been substituted for $2a_0/a_0$.