



Drag due to gaps round undeflected trailing-edge controls and flaps at subsonic speeds

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DRAG DUE TO GAPS ROUND UNDEFLECTED TRAILING-EDGE CONTROLS AND FLAPS AT SUBSONIC SPEEDS

CONTENTS

	Page
1. NOTATION AND UNITS	1
2. INTRODUCTION	3
3. CONTROL GAP EFFECTS	3
4. CONTROL GAP DRAG	4
4.1 Unsealed Gaps	5
4.1.1 Spanwise	5
4.1.2 Chordwise	6
4.2 Sealed Gaps	6
4.2.1 Spanwise	6
4.2.2 Chordwise	7
5. APPLICABILITY AND ACCURACY	7
5.1 Applicability	7
5.2 Accuracy	7
6. DERIVATION AND REFERENCES	9
6.1 Derivation	9
6.2 References	9
7. EXAMPLE	10
FIGURE 1	14

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DRAG DUE TO GAPS ROUND UNDEFLECTED TRAILING-EDGE CONTROLS AND FLAPS AT SUBSONIC SPEEDS

1. NOTATION AND UNITS (see Sketches 1.1 and 1.2)

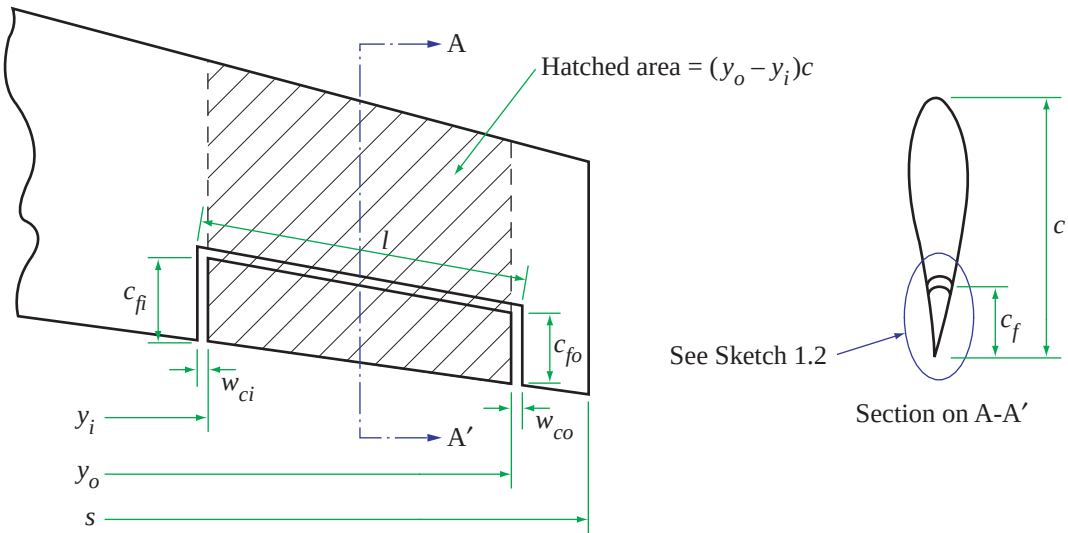
		SI	British
A	wing aspect ratio		
ΔC_D	drag coefficient increment based on free-stream kinetic pressure and wing reference area, S_{ref}		
$[\Delta C_{Dc}]_i$	drag coefficient increment due to inboard chordwise control gap, based on free-stream kinetic pressure and gap planform area $w_{ci} c_{fi}$		
$[\Delta C_{Dc}]_o$	drag coefficient increment due to outboard chordwise control gap, based on free-stream kinetic pressure and gap planform area $w_{co} c_{fo}$		
ΔC_{Ds}	drag coefficient increment due to spanwise control gap, based on free-stream kinetic pressure and gap planform area $w_s l$		
$\Delta C'_{Ds}$	drag coefficient increment due to spanwise control gap, based on free-stream kinetic pressure and wing area between control extremities, $(y_o - y_i)c$		
C_L	wing lift coefficient		
c	wing chord at mid-span of control	m	ft
c_f	control chord at mid-span of control	m	ft
c_{fi}, c_{fo}	control chord at inner, outer extremity	m	ft
G	spanwise gap parameter in Figure 1 and Equation (4.5)		
l	length of spanwise gap	m	ft
S_{ref}	wing reference area	m ²	ft ²
s	wing semi-span	m	ft
w_{ci}, w_{co}	width of inner, outer chordwise control gap	m	ft
w_s	average value of upper and lower spanwise control gaps, $\frac{1}{2}(w_{su} + w_{sl})$	m	ft
w_{sl}	spanwise gap normal to control surface for lower surface	m	ft

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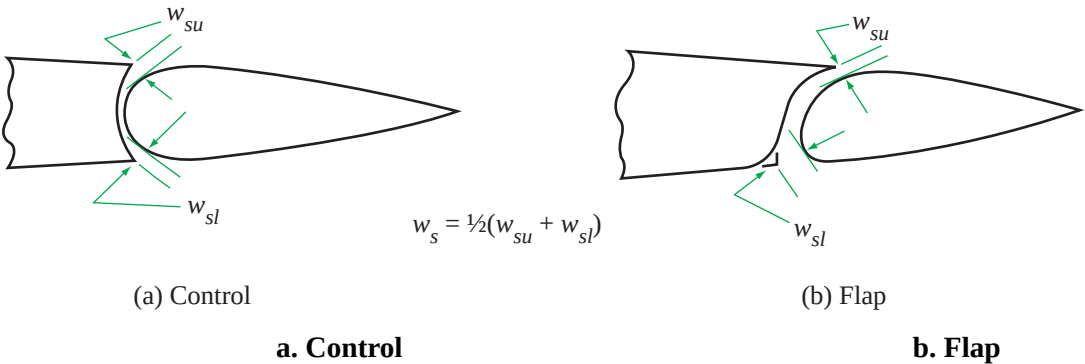
w_{su}	spanwise gap normal to control surface for upper surface	m	ft
y_i, y_o	spanwise location of inboard, outboard end of control	m	ft
λ	wing taper, tip chord/centre-line chord		

Subscripts

- ()*expt* denotes experimental value
- ()*pred* denotes predicted value



Sketch 1.1 Wing and control planform geometry



Sketch 1.2 Control spanwise gap geometry

2. INTRODUCTION

This Item provides methods for estimating the drag penalty due to gaps round undeflected trailing-edge controls and flaps on aircraft at subsonic speeds. The effects of gap geometry and the benefits of sealing are also considered. Although the Item is written in terms of controls the information is equally applicable to undeflected flaps. The qualitative effects of control gaps on the wing aerodynamic characteristics and the effect of control section and wing section profile mismatch on control gap drag are discussed in Section 3. The method of estimating the drag increment due to unsealed or sealed gaps is presented in Section 4. Section 5 outlines the applicability and provides an assessment of the accuracy. Section 6 lists the Derivations and References used in preparing the Item and Section 7 gives a worked example of the use of the methods.

3. CONTROL GAP EFFECTS

Gaps round controls are necessary to allow unhindered control movement under all flight conditions. However, even when the necessary gap widths are restricted to the minimum, they can have significant effects on the wing aerodynamic characteristics, as was shown in Derivation 2 for tests on a rectangular wing panel in two-dimensional flow. The wing was fitted with part-span trailing-edge controls with gaps of different widths, the spanwise gaps differing in profile from lower to upper surface according to the control leading-edge shape. The wing had a supercritical section (RAE 2815) and the tests were carried out for a Mach number of 0.665 over a range of lift coefficients up to about 0.7 and Reynolds numbers of 5, 10 and 15×10^6 based on wing chord.

The tests (Derivation 2) showed that a spanwise gap affects the chordwise pressure distribution over the full aerofoil. Under lifting conditions the loading on the forward part of the aerofoil, roughly ahead of maximum thickness, is increased while the loading in the vicinity of the gap suffers a significant decrease just upstream of the gap and a smaller increase just downstream. The net effect is a loss of overall lift and an increase in nose-up pitching moment.

The force tests showed that gaps round trailing-edge controls give

- (a) an increase in drag,
- (b) an increase in angle of attack at zero lift,
- (c) an increase in pitching moment at zero lift,
- (d) a slight decrease in lift-curve slope,
- (e) a minor forward shift in aerodynamic centre position.

The effects (a), (b) and (c) would still be expected with chordwise, but no spanwise, gaps. Data for the effect of spanwise gaps on lift-curve slope are given in Item No. Aero C.01.01.04 (Reference 4). It is also known that spanwise gaps affect the control characteristics. The influence on control effectiveness is dealt with in Reference 4 while methods for the effects on control hinge moments are referred to in Section 10 of Item No. Aero C.04.01.00 (Reference 5).