

TRANSONIC DRAG RISE OF RECTANGULAR SYMMETRICAL SECTION WINGS AT ZERO LIFT. NACA 65 series sections

1. NOTATION AND UNITS

		SI	British
A_N	net aspect ratio = $(b-D)^2/S$		
b	wing span	m	ft
C_{DW0}	wave drag coefficient based on net wing area S		
c	wing chord	m	ft
D	body diameter	m	ft
M	free-stream Mach number		
S	net wing area = $(b-D)c$	m ²	ft ²
t	maximum thickness of wing section	m	ft

2. NOTES

Figure 1 gives the variation of wave drag coefficient at zero lift with Mach number, aspect ratio and thickness/chord ratio for rectangular wings having symmetrical NACA 65 series sections. These data are plotted according to the transonic similarity law, and Figure 2 may be used to assist in the evaluation of the parameters employed.

The three-dimensional data (all within the range $0.5 \leq A_N(t/c)^{1/3} \leq 3.0$) were obtained from tests on wings fitted to bodies which were either rocket propelled or falling freely under gravity. In these tests the wing drag was measured either directly by a balance, or indirectly by the difference between the drag of the wing-body combination and the drag of the body alone as obtained from deceleration measurements. In all cases the body was of circular section and of constant diameter in the vicinity of the wing. The ratios of span to body diameter, b/D , for the models used in the tests were in the range 3.8 to 5.7 and the Reynolds numbers, based on wing chord, were between 2 and 8×10^6 . There is insufficient evidence at present available to indicate systematic variation in wave drag coefficient either with b/D or with Reynolds number.

The two-dimensional data ($A_N(t/c)^{1/3} = \infty$) were taken from wind tunnel tests on a wing of NACA 65A009 section at subsonic speeds and a wing of NACA 65-009 section at supersonic speeds. The Reynolds number range for the former tests was 0.7 to 1.6×10^6 , while for the latter it was 0.8 to 1.1×10^6 . It would appear from two-dimensional tests on other sections that thickness distribution does not affect the collapse of two-dimensional data, using transonic similarity parameters, as much as for three-dimensional data, so that the use of the NACA 65A section is probably justified.

The curves for $3.0 < A_N(t/c)^{1/3} < \infty$ have been interpolated since no experimental data for this range are currently available.

The data used are as accurate as can be expected for test data, but the presentation provides certain limitations in accuracy, particularly for the three-dimensional data in which a considerable amount of scatter occurs, of the order ± 25 per cent. The effects of surface finish, transition position, Reynolds number etc. are not easily allowed for in the data reduction, and probably account for a large percentage of the scatter.

In view of the inaccuracies involved it is advised that this Data Item be used for qualitative guidance only, and even in this capacity its use should be restricted to wings of NACA 65 series section.

3. DERIVATION

The Derivation lists selected sources that have assisted in the preparation of this Item.

1. HERBERT, P.J. A summary of test on the transonic drag of rectangular wings at zero lift. RAE TN Aero. 2157, 1952.
2. DALEY, B.N.
DICK, R.S. Effect of thickness, camber, and thickness distribution on airfoil characteristics at Mach numbers up to 1.0. NACA TN 3607, 1952.

4. EXAMPLE

Estimate the order of the rise in drag coefficient above the low speed value, at a Mach number of 1.10, for a wing of net aspect ratio 3.0 having an NACA 65-009 section.

From Figure 2, for $t/c = 0.09$,

$$(t/c)^{1/3} = 0.448 \quad \text{and} \quad (t/c)^{5/3} = 0.0181.$$

Hence

$$A_N(t/c)^{1/3} = 3.0 \times 0.448 = 1.34$$

$$\text{and} \quad \frac{(|M^2 - 1|)^{1/2}}{(t/c)^{1/3}} = \frac{(1.21 - 1)^{1/2}}{0.448} = 1.02.$$

From Figure 1,

$$\frac{C_{DW0}}{(t/c)^{5/3}} = 2.6$$

and hence

$$C_{DW0} = 2.6 \times 0.0181 = 0.047 \approx 0.05.$$