

DRAG OF A SMOOTH FLAT PLATE AT ZERO INCIDENCE

1. NOTATION

		SI	British
C_{D0}	drag coefficient, based on plate area (<i>i.e.</i> on half wetted area)		
c	length of plate (corresponding to wing chord)	m	ft
R	Reynolds number, Vc/ν		
V	velocity of airflow	m/s	ft/s
ν	kinematic viscosity	m ² /s	ft ² /s
ρ	density	kg/m ³	slug/ft ³

2. NOTES

The drag coefficient of an aerodynamically smooth flat plate at zero incidence is plotted against Reynolds number for various positions of transition from laminar to turbulent flow in the boundary layer. Figure 1a covers the range of low Reynolds numbers and Figure 1b that of high Reynolds numbers.

The data for the fully laminar flow are derived from Blasius' theory and those for the fully turbulent flow from von Kármán's empirical formula. The curves for partly laminar and partly turbulent flow are taken from calculations by Squire and Winterbottom, and values for transition beyond $0.6c$ have been extrapolated to the values for fully laminar flow. It is assumed that the transition occurs on both sides of the plate at the same distance behind the leading edge.

When obtaining the profile drag of wings using Item Nos Aero W.02.04.02 and 03, which take account of type of wing section and wing thickness, the data in this Item must be used. For more recent information concerning skin friction and other parameters for laminar and turbulent boundary layers on a smooth flat plate, Item Nos 68019 and 68020 should be consulted.

3. DERIVATION

1. KARMAN, TH. VON. Turbulence and skin friction.
J. aeronaut. Sci., Vol.1, pp. 1-30, 1934.
2. DURAND, W.F. *Aerodynamic theory*, Vol. 3.
(Editor) Springer, Berlin, 1935.
3. WINTERBOTTOM, N.E. Note on further profile drag calculations.
SQUIRE, H.B. RAE Rep. BA 1634, 1940.

4. LOCK, R.C.

Note on profile drag calculations for low drag wings with cusped trailing edges.

RAE Rep. Aero 2130, 1946

4. EXAMPLE

Find the drag, D , of an aerodynamically smooth flat plate at zero incidence in an air flow at a velocity of 500 ft/s at sea level ($\rho = 2.377 \times 10^{-3}$ slug/ft³ and $\nu = 157.2 \times 10^{-6}$ ft²/s). For both surfaces of the plate the flow is assumed to be laminar up to 0.55c. The width of the plate is 9 ft and its length 3 ft.

$$\text{Reynolds number, } R = \frac{Vc}{\nu} = \frac{500 \times 3}{157.2 \times 10^{-6}} = 9.5 \times 10^6.$$

From Figure 1b

$$C_{D0} = 0.00355.$$

Therefore

$$\begin{aligned} D &= 0.00355 \times \frac{1}{2} \times 2.377 \times 10^{-3} \times 500^2 \times 27 \\ &= 28.5 \text{ lbf.} \end{aligned}$$