



The low-speed stalling characteristics of aerodynamically smooth aerofoils

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* Corresponding Member

The person with overall responsibility for the work in this subject area is Mr R.W. Gilbey, Head of Aircraft Aerodynamics Group.

THE LOW-SPEED STALLING CHARACTERISTICS OF AERODYNAMICALLY
SMOOTH AEROFOILS

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THE LOW-SPEED STALLING CHARACTERISTICS OF AERODYNAMICALLY SMOOTH AEROFOILS

1. NOTATION (see Figure 2)

		SI	British
c	aerofoil chord	m	ft
R_c	Reynolds number based on aerofoil chord		
$z_{1.25}$	aerofoil upper-surface ordinate at 1.25 per cent chord station	m	ft

2. NOTES

Figure 1, which is taken from Derivation 1, gives a qualitative guide to the stalling characteristics of aerofoils based on the parameters Reynolds number, R_c , and upper-surface ordinate (expressed as a fraction of the chord) at the 1.25 per cent chord station, $z_{1.25}/c$ (see Figure 2)*. The choice of $z_{1.25}/c$ as a parameter was based solely on its ability to give the most distinct correlation. Table 5.1 lists values of $z_{1.25}/c$ for many commonly used NACA and RAE series of aerofoils.

Figure 1 is based on a correlation of about 700 stalls on 150 different NACA aerofoil sections (both symmetrical and cambered) over a range of Reynolds numbers from 0.7×10^6 to 25×10^6 . Where possible the negative stall as well as the positive stall was used, together with the appropriate "upper-surface" ordinate $z_{1.25}/c$, as shown on Figure 2. All the data were obtained from low-speed tests on aerodynamically smooth aerofoils in the NACA low-turbulence wind tunnel. Known data for aerofoils tested in British wind-tunnel facilities are also in agreement with the correlation.

The stalling characteristics were determined for each aerofoil by a careful study of the lift, drag and pitching moment characteristics. A typical lift characteristic for each type of stall and the corresponding flow picture for incidences just prior to the stall are shown in Figures 3 and 4, respectively. The various types of stall can be classified as follows.

A. Trailing-edge stall - gradual and continuous force and moment variations, with a well-rounded lift-curve peak. The stall is preceded by a steady movement of the turbulent boundary-layer separation point forward from the trailing edge with increasing incidence.

B. Leading-edge stall - little or no change in lift-curve slope prior to maximum lift, and an abrupt (often large) decrease in lift after maximum lift has been attained. This type of stall is due to the presence of a laminar separation bubble (of very small chordwise extent, typically $0.005c$ to $0.01c$) near the leading edge. As incidence is increased the bubble moves forward nearer the leading edge until it eventually bursts causing full-chord flow separation.

C. Thin-aerofoil stall - a rounded lift-curve peak, generally preceded by a discontinuous force and moment variation for aerofoils with a rounded leading edge. This type of stall is also due to the presence of a laminar separation bubble near the leading edge. As incidence increases the reattachment point moves steadily rearward until it coincides with the trailing edge, at about which stage maximum lift is reached.

* It should be stressed that the correlation in Figure 1 was developed using the value of $z_{1.25}/c$ yielded by the method of adding the thickness distribution normal to the mean line. This method must therefore be adhered to when using this Item.