



ESDU 74008

Issued April 1974

With Amendments A

May 1975

Supersedes ESDU Aero 00.03.01

Aero 00.03.02

Estimation of critical Mach number for an aerofoil from its low-speed pressure distribution

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item which supersedes ESDU Aero 00.03.01 and 00.03.02, was monitored and guided by the Aerodynamics Committee. This Committee first met in 1942 and now has the following membership:

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ESTIMATION OF CRITICAL MACH NUMBER FOR AN AEROFOIL FROM ITS LOW-SPEED PRESSURE DISTRIBUTION

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ESTIMATION OF CRITICAL MACH NUMBER FOR AN AEROFOIL FROM ITS LOW-SPEED PRESSURE DISTRIBUTION

1. NOTATION AND UNITS

		SI	British
B	Wilby* compressibility factor, $[1 - M_0^2(1 - M_0 C_{pi})]^{1/2}$ (see Section 6 of Reference 4)		
C_{pi}	local pressure coefficient in incompressible flow		
c	aerofoil chord, <i>i.e.</i> length of line joining trailing edge (assumed sharp) and that unique point at which a circle centred at the trailing edge is tangential to the aerofoil	m	ft
M_{crit}	critical Mach number, <i>i.e.</i> free-stream Mach number for which, at given incidence, maximum local velocity on aerofoil is just sonic		
M_0	free-stream Mach number for which, at given incidence, sonic velocity occurs at given chordwise location		
x	chordwise distance aft of aerofoil leading-edge	m	ft
z	ordinate at station x , measured perpendicular to chord line	m	ft
z_c	camber line ordinate at station x , $\frac{1}{2}(z_u + z_l)$	m	ft
z_l	ordinate of aerofoil lower-surface	m	ft
z_t	ordinate of thickness distribution at station x , $\frac{1}{2}(z_u - z_l)$	m	ft
z_u	ordinate of aerofoil upper-surface	m	ft
θ	slope of aerofoil surface relative to chord line, $\tan^{-1}(dz_c/dx + dz_t/dx)$ for the upper surface and $\tan^{-1}(dz_c/dx - dz_t/dx)$ for the lower surface	rad	rad

* Sometimes referred to as Lock-Wilby.

2. INTRODUCTION

Calculations of pressure distribution around an arbitrary aerofoil in two-dimensional compressible flow require the use of a digital computer¹⁰ (for example Firmin¹¹ for viscous subcritical flow, Sells⁵ or Jones¹² for inviscid subcritical flow, Albone⁸ for just-supercritical shock-free flow, Krupp and Murmann⁷ or Bauer, Garabedian and Korn⁹ for supercritical flow with shocks). The increasing complexity of these numerical methods has created a need for an Item providing a rapid means of estimating the critical Mach number. A knowledge of the critical Mach number is normally needed in planning a series of calculations by any of the methods mentioned and may even help in the choice of a particular method.

Issued April 1974 – 8 pages
With Amendment A, June 1986