

SUPERSONIC BASE PRESSURE OF CYLINDRICAL BODIES

1. NOTATION AND UNITS

		SI	British
C_{pb}	base pressure coefficient, $(p_b - p_1)/\frac{1}{2}\gamma p_1 M_1^2$		
d_p	diameter of base	m	ft
M_1	Mach number outside boundary layer at base of body		
p_b	base pressure	N/m ²	lbf/ft ²
p_1	static pressure outside boundary layer at base of body	N/m ²	lbf/ft ²
γ	ratio of specific heat capacity at constant pressure to specific heat capacity at constant volume for air		
θ	boundary layer momentum thickness	m	ft

2. NOTES

The pressure on the base of a body of revolution in supersonic flow is determined partly by the manner in which the pressure in the wake recovers to ambient conditions far downstream but chiefly by the local conditions outside the boundary layer at the base (see, for example, Derivations 6 and 20). For this reason the base pressure coefficient is defined in terms of these local conditions (p_1 , M_1). The present Item is restricted to bodies which have long cylindrical sections (of three or more body diameters) immediately upstream of the base so that the disturbance created by the nose is small and the local conditions differ little from free-stream values. The data apply to bodies with a plain base, or to bases containing a jet orifice provided that there is no jet flow. Tests on configurations with base bleeds have shown that even very small jet flows can have a significant effect on base pressure, see, for example, Derivations 1 and 10.

Figure 1 presents the base pressure coefficient for bodies with boundary layers that are fully turbulent over the body length. It was developed from an analysis of the experimental data in Derivations 1 to 30. When the flow over the body is turbulent the variation of C_{pb} with Reynolds number is fairly small and is associated with changes in boundary layer thickness (see, for example, Derivations 1 and 10). Due to the scatter in the experimental data it has not been possible to establish a correlation in boundary layer thickness to allow for this small effect. For values of d_b/θ above 60, Figure 1 generally predicts C_{pb} to within ± 10 per cent.

Experimental evidence (Derivations 20, 23 and 27) indicates that when the boundary layer over the body is laminar the base pressure is strongly dependent on the position of the transition point in the wake. As the transition point moves upstream, the base pressure falls from a maximum value (transition downstream of the point of confluence of the separated layers) to a minimum value corresponding to transition in the separated layers. The extreme values of C_{pb} are shown in Figure 2 as a function of Mach number, the line of minimum values corresponding approximately to the base pressure coefficient with turbulent boundary layer flow over the body. The variation of the transition position (and hence C_{pb}) is dependent on such factors as the free-stream turbulence level. It is not possible to account precisely for such effects and the variation of C_{pb} , when transition occurs downstream of the base, is therefore not accurately predictable.

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3. DERIVATION

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

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13. LOVE, E.S. Base pressure at supersonic speeds on two-dimensional airfoils and on bodies of revolution with and without fins having turbulent boundary layers. NACA tech. Note 3819, 1953.
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